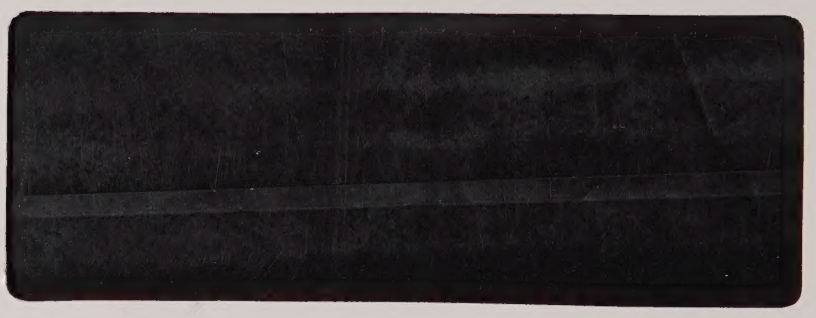
# INSTRUCTION MANUAL

# RACAL-DANA

RACAL

The Electronics Group



PUBLICATION NO. 980603

PRELIMINARY

# 9085

## PROGRAMMABLE LOW DISTORTION OSCILLATOR

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PUBLICATION DATE: AUGUST 1985

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# FOR YOUR SAFETY

Before undertaking any maintenance procedure, whether it be a specific troubleshooting or maintenance procedure described herein or an exploratory procedure aimed at determining whether there has been a malfunction, read the applicable section of this manual and note carefully the WARNING and CAUTION notices contained therein.

The equipment described in this manual contains voltage hazardous to human life and safety and which is capable of inflicting personal injury. The cautionary and warning notes are included in this manual to alert operator and maintenance personnel to the electrical hazards and thus prevent personal injury and damage to equipment.

If this instrument is to be powered from the AC line (mains) through an autotransformer (such as a Variac or equivalent) ensure that the common connector is connected to the neutral (earthed pole) of the power supply.

Before operating the unit ensure that the protective conductor (green wire) is connected to the ground (earth) protective conductor of the power outlet. Do not defeat the protective feature of the third protective conductor in the power cord by using a two conductor extension cord or a three-prong/two-prong adaptor.

Maintenance and calibration procedures contained in this manual sometimes call for operation of the unit with power applied and protective covers removed. Read the procedures carefully and heed Warnings to avoid "live" circuit points to ensure your personal safety.

Before operating this instrument:

1. Ensure that the instrument is configured to operate on the voltage available at the power source. See Installation Section.

2. Ensure that the proper fuse is in place in the instrument for the power source on which the instrument is to be operated.

3. Ensure that all other devices connected to or in proximity to this instrument are properly grounded or connected to the protective third-wire earth ground.

If at any time the instrument:

- Fails to operate satisfactorily
- Shows visible damage
- Has been stored under unfavorable conditions
- Has sustained stress

It should not be used until its performance has been checked by qualified personnel.

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# SECTION 1 GENERAL DESCRIPTION

## 1.1 INTRODUCTION

1.1.1 The LDO is a Low Distortion Oscillator covering the frequency range 9 Hz to 330 kHz. Refer to the block diagram shown in Figure 1.1.

1.1.2 The MAIN output provides sinewave signals from 0.66 mV to 7 V RMS in amplitude. The AUXiliary output provides rectangular pulses suitable for triggering both TTL and CMOS logic. It can also be used as a low current variable DC source. A QUADRATURE output is available at the back panel of the instrument.

1.1.3 A Liquid Crystal Display indicates the operating conditions. Frequency and voltage are displayed simultaneously. Each can have up to four digits. Annunciators indicate the units. The display extensively guides the user through the instrument's functions.

1.1.4 RS-232 and IEEE-488 interfaces allow remote programming of all the instrument's capabilities.

1.1.5 Ten non-volatile memory locations are available for storing the instrument's status settings.

1.1.6 Self-calibration of the frequency ranges can be initiated from the front panel or remotely.

1.1.7 Although all the oscillator hardware is microprocessor-controlled, the ergonomics of a traditional bench instrument have been preserved.

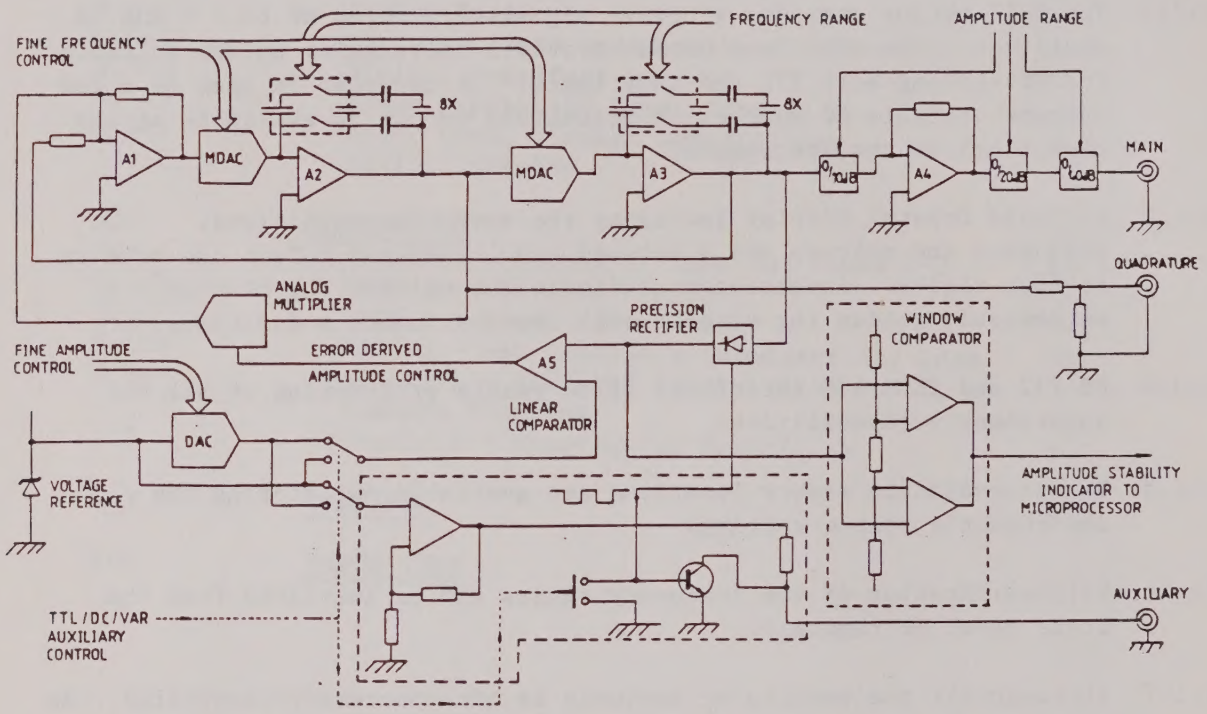



*Figure 1.1 - Block Diagram, LDO 9085*

## 1.2 SPECIFICATIONS

### FREQUENCY RANGES:

| | | | |
|---|---|---|---|
| 1 | 9 | - | 101 Hz |
| 2 | 95 | - | 332 Hz |
| 3 | 300 | - | 1050 Hz |
| 4 | 950 | - | 3320 Hz |
| 5 | 3.0 | - | 10.5 kHz |
| 6 | 9.5 | - | 33.2 kHz |
| 7 | 30 | - | 105 kHz |
| 8 | 95 | - | 332 kHz |

### FREQUENCY, ACCURACY, AND STABILITY:

Load Condition : 600 ohms and less than 50 pF

20 Hz - 100 kHz :

+/- 0.5%, +/- 1 display digit

9 Hz - 332 kHz:

+/- 3%, +/- 1 display digit

Frequency Resolution:

Better than 1 part in 3000 of full scale in each frequency range

Temperature coefficient:

Better than 350 ppm/°C

Thermal time constant:

90 minutes

MAIN OUTPUT:

Amplitude Ranges: rms, output unloaded

| | |
|---|---|
| 1 | 0.665 - 2.21 mV |
| 2 | 2.10 - 7.00 mV |
| 3 | 6.65 - 22.1 mV |
| 4 | 21.0 - 70.0 mV |
| 5 | 66.5 - 221 mV |
| 6 | 210 - 700 mV |
| 7 | 0.665 - 2.21 V |
| 8 | 2.10 - 7.00 V |

Distortion and Noise:

| Freq-range | Value | Load Condition | |
|---|---|---|---|
| 20 Hz - 20 kHz | less than 0.01% | 600 ohms | See note 1 |
| 9 Hz - 50 kHz | " " 0.03% | 600 ohms | See note 2 |
| 50 kHz - 100 kHz | " " 0.1% | 600 ohms | See note 3 |
| 100 kHz - 332 kHz | " " 1% | 600 ohms | Sëe note 3 |

Amplitude Accuracy and Stability:

Load Condition : 600 ohms and less than 50 pF

Accuracy between display and output:

+/- least significant display increment,
+/- 0.25 dB at 1 kHz

Deviation with changing frequency, with reference to 1 kHz:

| | | | |
|---|---|---|---|
| 20 Hz | - 20 kHz | +/- | 0.1 dB |
| 9 Hz | - 100 kHz | +/- | 0.25 dB |
| 9 Hz | - 330 kHz | +/- | 0.5 dB |

Settling Time: Less than 50 Hz-sec

Temperature coefficient:

Better than 300 ppm/°C

Output Impedance:

600 ohms +/- 1% unbalanced

AUXILIARY OUTPUT:

TTL:

1:3 mark-space rectangular pulse

Rising edge coincident with rising zero crossing of main output

Falling edge coincident with positive peak of main output

Output Voltage:

4.25 volts, +/- 0.25 volts

Output Impedance:

50 ohms, +/- 10%

Rise and Fall Times:

Better than 100 ns

Maximum short circuit output current:

300 mA approximately

Variable:

1:3 mark-space rectangular pulse

Rising edge coincident with rising zero-crossing of main output

Falling edge coincident with positive peak of main output

Output Voltage Range:

0.1 to 12 volts peak, unloaded

Output Impedance:

50 ohms, +/- 10%

Rise and Fall Times:

Better than 100 ns

Accuracy between Display and Output:

+/- 1 digit, +/- 0.5% of full scale

Maximum short circuit current:

300 mA approximately

Maximum current at 12 volts peak output

10 mA approximately

DC

Output Voltage Range:

0.1 to 12 volts peak unloaded.

Output Impedance:

50 ohms, +/- 5%

Accuracy between Display and Output:

+/- 1 digit, +/- 0.5% of full scale.

Maximum short circuit current:

145 mA +/- 10%

Maximum current at 12 volts output:

10 mA approximately.

QUADRATURE OUTPUT:

Output Voltage Range:

69 - 229 mV, +/- 6% following the fine setting of the Main Output

Output Impedance:

600 ohms +/- 5%

OPERATING TEMPERATURE RANGE:

0 - 35°C

POWER REQUIREMENTS:

100 - 130 V rms, 50/60 Hz @ 35 VA

AC LINE:

1 AT

PHYSICAL DIMENSIONS:

Weight:

6.8 kg

Dimensions:

95 mm. Height
360 mm. Width
295 mm. Depth

(excluding the handle)

Note 1 - Bandwidth limited to 80 kHz amplitude ranges 5 - 8

Note 2 - Bandwidth limited to 200 kHz amplitude ranges 5 - 8

Note 3 - Bandwidth limited to 1 MHz amplitude ranges 5 - 8

# SECTION 2 INSTALLATION

## 2.1 INTRODUCTION

2.1.1 This section of the manual contains preparatory information for the correct operation of the LDO 9085. It is recommended that this section be read and understood before attempting to operate the instrument. Should any difficulties arise during operation, please contact your nearest Racal-Dana representative or write to:

Racal-Dana Instruments,
4 Goodyear Street,
P.O. Box C-19541
Irvine,
California 92713,
U.S.A.

## 2.2 UNPACKING AND INSPECTION

2.2.1 The LDO 9085 is shipped in a heavy-duty cardboard container with shock absorbent, foam rubber spacers, especially designed to provide adequate protection. On receipt, inspect the instrument for possible transit damage.

## 2.3 RESHIPMENT INSTRUCTIONS

2.3.1 If reshipment of the instrument is ever necessary, it is advisable to use the original packing. If this is not available, a new container can be obtained from Racal-Dana Instruments.

## 2.4 PREPARATION FOR USE

2.4.1 Remove the LDO 9085 from its packing and connect a suitable 3-pin AC plug to the cable, ensuring that the following color connection code is observed:

| | | American | European |
|---|---|---|---|
| LIVE | - | Black | Brown |
| NEUTRAL | - | White | Blue |
| GROUND(EARTH) | - | Green | Green/Yellow |

2.4.2 The handle of the LDO can be used either as a carrying handle, or it can be folded under the instrument in order to tilt the front panel for convenient use.

## 2.5 POWER SUPPLY

### 2.5.1 Supply Requirements and AC Line

2.5.1.1 The LDO is supplied for operation on nominal 120 line voltage. The AC line transformer can be wired to permit operation from 120 or 240 volts. Wiring of the transformer is intended to be done only at manufacture, not by the user.

2.5.1.2 For 240 volt operation, the two primary windings of the transformer should be wired in series, as shown in Figure 2.1.

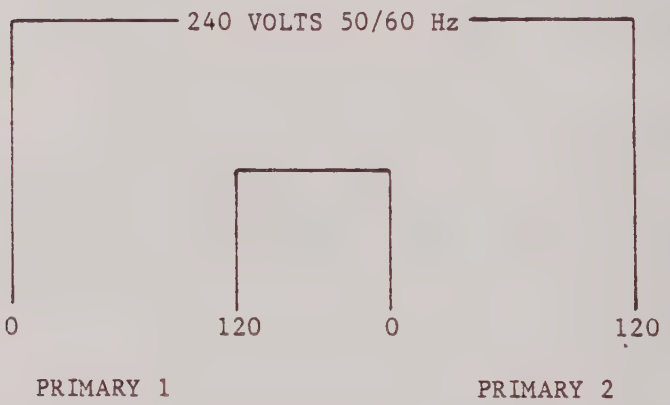



**Figure 2.1 - Primary Terminals of AC Line Transformer**

2.5.1.3 For 120 volt operation, the AC line fuse should be 1A slow-blow. No other type or rating should be installed.

The AC line fuse is positioned on the back panel. Isolate the LDO from the AC line before removing or replacing the fuse.

### 2.5.2 Power-On

2.5.2.1 After having connected a suitable AC line plug to the AC input lead, connect the instrument to the power source. To turn the instrument ON, press the red push button located on the front right hand side of the instrument. The LDO turns ON all the segments of the display for a period of 1 second as a display check. Normal operation then proceeds with the frequency and amplitude set in the lowest range, and the Auxiliary Output set to TTL.

### 2.5.3 Acceptance Checks

2.5.3.1 Set the ADDRESS SWITCHES at the back panel as follows:

| | |
|---|---|
| SWITCHES 4 and 5 | DOWN |
| ALL OTHERS | UP |

2.5.3.2 Ensure front panel AC line switch is in OFF position.

2.5.3.3 Connect the AC line cord to a suitable line outlet.

2.5.3.4 Turn frequency and amplitude pots fully counterclockwise.

### 2.5.4 Front Panel Check

2.5.4.1 Observing the display, switch on the unit and check that all segments are shown for a short period before going to frequency and voltage readings only.

2.5.4.2 Press front-panel buttons in the following sequence and check the display.

NOTE (a) Other characters may be present as well as those being checked.

(b) xxx means numbers but not necessarily the correct amount of numbers.

| BUTTON | | DISPLAY |
|---|---|---|
| PERIOD | (2) | xxx ms or μs |
| FREQ NORM | (3) | 1.000 N |
| REF | (6) | xxx Hz or kHz (Momentarily) |
| dBm | (8) | xxx dBm |
| dBREL | (9) | 0.0 db |
| VOLTS | (7) | xxx V or mV |
| VAR | (0) | VAr Then U xxx V |
| DC | (*) | dC Then d xxx V |
| PAGE | (N) | P = 00 |
| PAGE | (0) | Returns to normal |
| LOCAL | | Addr = 07 (Momentarily) |
| TTL | (.) | ttl Then xxx V or mV |
| FREQ | (1) | xxx Hz or kHz |
| FREQ RANGE | | Freq steps up |
| FREQ RANGE | | Freq steps down |
| AMP RANGE | | Amp steps up |
| AMP RANGE | | Amp steps down |

2.5.4.3 Rotate amplitude pot and check that the amplitude varies over the complete range of rotation.

2.5.4.4 Rotate frequency pot and check that the frequency varies over the complete range of rotation. Leave pot set at its mid point (approx).

2.5.4.5 Press FINE (5) button.

2.5.4.6 Check that the frequency pot varies the frequency by approx. +/-5%.

2.5.4.7 Press COARSE (4) button.

2.5.4.8 Check that the frequency pot now changes the frequency over the complete range.

**2.5.5 Frequency Accuracy**

2.5.5.1 Using the frequency range button, select range 8.

2.5.5.2 Set frequency meter to:

LO FREQ
GATE at 1s

2.5.5.3 Connect frequency meter to AUX O/P.

2.5.5.4 Using table 2.5.5.8 decide upon 3 ranges to check and repeat steps 2.5.5.5 and 2.5.5.6 checking one frequency in each of those ranges.

2.5.5.5 In descending order, select the range required and set the display to the frequency required using the FINE and COARSE buttons as required.

NOTE If the range being checked is 3 or below then reset the frequency meter as per SPECIAL NOTE at 2.5.5.9.

2.5.5.6 Check that the frequency meter reads within the limits shown in table 2.5.5.8

2.5.5.7 Proceed to 2.5.6.

2.5.5.8

| OSCILLATOR DISPLAYED FREQUENCY | RANGE | FREQUENCY METER READING |
|---|---|---|
| 332.0 KHz | | 321.94 - 342.06 KHz |
| 213.0 | 8 | 206.50 - 219.50 |
| 95.1 | | 92.15 - 98.05 |
| 105.0 | | 104.37 - 105.60 |
| 67.5 | 7 | 67.06 - 67.94 |
| 30.0 | | 29.75 - 30.23 |
| 33.2 | | 33.02 - 33.37 |
| 21.30 | 6 | 21.18 - 21.42 |
| 9.5 | | 9.44 - 9.56 |
| 10.5 | | 10.44 - 10.56 |
| 6.75 | 5 | 6.70 - 6.79 |
| 3.0 | | 2.97 - 3.025 |
| 3.32 | | 3.302- 3.338 |
| 2.135 | 4 | 2.123- 2.147 |
| 1.5 | | 1.492- 1.509 |
| 1050 Hz | | 958.08 - 946.7 µs |
| 675 | 3 | 1.491- 1.472 ms |
| 300 | | 3.36 - 3.306 |
| 332.0 | | 3.03 - 2.996 |
| 213.0 | 2 | 4.721- 4.669 |
| 95.0 | | 10.59 -10.463 |
| 101.0 | | 9.961- 9.842 |
| 55.1 | 1 | 18.273-18.026 |
| 10.5 | | 96.637-93.87 |

2.5.5.9 **SPECIAL NOTE** Long gate times are required to accurately check low frequencies and it is therefore more advantageous to measure PERIOD on Range 3 and below.

Set frequency meter as follows:

TIME AV PER
GATE @ .01s

Continue check at 2.5.5.6.

### 2.5.6 Main Output Amplitude Accuracy

2.5.6.1 Disconnect the frequency meter from AUX O/P.

2.5.6.2 Connect a DVM to MAIN O/P.

2.5.6.3 Set oscillator display to read approx 1 kHz on range 4.

2.5.6.4 Using Table 2.5.6.6, select any 3 ranges and set oscillator display to the value for each range in turn. Check that the DVM reading is within the limits shown.

NOTE To check on Range 1 or 2, the DVM will have to be replaced by a microvoltmeter.

2.5.6.5

| OSCILLATOR DISPLAYED VALUE | RANGE | METER READING (+/-1 DIGIT +/-2.5%) |
|---|---|---|
| 1.50 mV | 1 | 1.453 - 1.548 mV |
| 4.70 | 2 | 4.573 - 4.828 |
| 15.0 | 3 | 14.530 - 15.480 |
| 47.0 | 4 | 45.73 - 48.280 |
| 150 | 5 | 145.30 -154.80 |
| 470 | 6 | 457.30 -482.80 |
| 1.50 V | 7 | 1.453 - 1.548 V |
| 2.10 | 8 | 2.038 - 2.163 |
| 7.00 | 8 | 6.815 - 7.185 |

## 2.5.7 Main Amplitude Accuracy With Changing Frequency

2.5.7.1 Connect a DVM to MAIN O/P.

2.5.7.2 Set oscillator to amplitude range 7 and adjust amplitude control until DVM reads 1.000 V.

2.5.7.3 Using Table 2.5.7.4 set the oscillator display to any 2 frequencies in each band and check that the DVM reading is within the limits shown.

2.5.7.4

| FREQUENCY BAND | RANGES | DVM READING VOLTS |
|---|---|---|
| 20 Hz to 20 KHz | 1 to MID 6 | .988 to 1.012 |
| 20 KHz to 100 KHz | MID 6 to 7 | .9708 to 1.03 |
| 100 KHz to 330 KHz | 8 | .941 to 1.059 |

## 2.5.8 Aux Output

2.5.8.1 Disconnect DVM from MAIN O/P and reconnect it to AUX O/P.

2.5.8.2 Press DC (*) button.

2.5.8.3 Set amplitude on oscillator display to 12.0 V and frequency to approx 1 KHz on Range 4.

2.5.8.4 Set DVM to read DC.

2.5.8.5 Check that DVM reads between 11.85 and 12.15 volts.

2.5.8.6 Set oscillator display to read 6.0 volts and check that DVM reads between 5.87 and 6.13 volts.

2.5.8.7 Set oscillator amplitude control to minimum and check that DVM reads less that 0.120 volts.

2.5.8.8 Disconnect DVM from AUX O/P.

2.5.8.9 Connect oscilloscope CH1 to AUX O/P.

2.5.8.10 Set oscilloscope CH1 to:

2 V/cm
Timebase .5 ms

Switch to GND and zero trace on second graticule up.
Switch to DC.

2.5.8.11 Select VAR on oscillator and check that the oscillator display value remains the same.

2.5.8.12 Rotate oscillator amplitude control to maximum and check that peak amplitude on oscilloscope is between 11.9 and 12.1 volts measured from the second graticule.

2.5.8.13 Select TTL on oscillator.

2.5.8.14 Check that the peak amplitude on the oscilloscope is between 4.0 and 4.5 volts measured from the second graticule.

**2.5.9 Quadrature Output**

2.5.9.1 Connect DVM to QUADRATURE O/P.

2.5.9.2 Disconnect oscilloscope from AUX O/P.

2.5.9.3 Set amplitude pot to minimum.

2.5.9.4 Check that DVM reads between 64.86 and 73.14 mV.

2.5.9.5 Set amplitude pot to maximum.

2.5.9.6 Check that DVM reads between 215.26 and 242.74 mV.

2.5.9.7 Disconnect DVM from QUADRATURE O/P.

2.5.9.8 Connect oscilloscope CH1 to MAIN O/P and CH2 to QUADRATURE O/P.

2.5.9.9 Check that Quadrature O/P is 90° phase shifted with respect to the Main O/P.

2.5.9.10 Disconnect oscilloscope.

## 2.5.10 Noise and Distortion

2.5.10.1 Connect a distortion meter to MAIN O/P.

2.5.10.2 Set distortion meter switches as follows:

FUNCTION ON DISTORTION
METER RESPONSE ON NORM
DISTORTION RANGE )
I/P RANGE ) AS REQUIRED
FREQ. )
FILTERS AS SHOWN IN TABLE 2.5.10.5

2.5.10.3 Make 2 checks of distortion at each frequency shown in TABLE 2.5.10.5 using any amplitude settings in Ranges 5, 6, 7 or 8.

2.5.10.4 Disconnect distortion meter.

2.5.10.5

| FREQUENCY | FREQUENCY RANGE | DISTORTION METER FILTER | DISTORTION % (LESS THAN) |
|---|---|---|---|
| 10 Hz | 1 | 80 KHz | 0.03 |
| 20 Hz | 1 | 80 KHz | 0.01 |
| 20 KHz | 6 | 80 KHz & 400 Hz | 0.01 |
| 50 KHz | 7 | * See note | 0.03 |
| 100 KHz | 7 | 400 Hz | 0.1 |
| 100 KHz | 8 | NONE | 1.0 |

*NOTE
Use 400 Hz filter and connect 1200 pf capacitor across distortion meter I/P.

## 2.5.11 IEEE Test. Setting Up (Using Computer Keyboard)

2.5.11.1 Connect the oscillator to an IEEE-488-controller.

2.5.11.2 Run a program that will send characters to the oscillator at address 7 from the keyboard and print strings of characters received from the oscillator. See Appendix 5.2.2, sample for HP85.

2.5.11.3 Type L (RETURN) and check that rem annunciator on oscillator display is lit and "listen" lamp is on.

2.5.11.4 Rotate frequency pot and check that the display does <u>not</u> change.

2.5.11.5 Type U (RETURN).

2.5.11.6 Rotate frequency pot and check that the display <u>does</u> change.

### 2.5.12 IEEE Functional Check (Using Computer Keyboard)

NOTE Press RETURN after entering commands during the following checks.

2.5.12.1 Type L (RETURN)

2.5.12.2 Enter any 4 of the following commands and check that the oscillator response is correct.

| COMMAND | OSCILLATOR RESPONSE |
|---|---|
| F 9Hz | 9.0 Hz |
| F 10 KHz | 10.0 KHz |
| F 330 KHZ | 330.0 KHz |
| A .665 mV | 0.665 mV |
| A 1 V | 1.00 V |
| A 7 V | 7.00 V |
| P 3.03 µS | 3.03 µS |
| P 1 mS | 1000 µS |
| P 110 mS | 110.0 mS |
| D 0.01 V | d 0.0 V |
| D 0.1 V | d 0.1 V |
| D 12.0 V | d 12.0 V |
| V 0.01 V | U 0.0 V |
| V 0.1 V | U 0.1 V |
| V 12.0 V | U 12.0 V |

2.5.12.3 Enter F 1 KHz

2.5.12.4 Using any number between 1 and 7, inclusive, in place of X, enter the following 2 commands and check that the response is correct. Also note that the display "blinks" when RETURN is pressed for the second command.

| COMMAND | RESPONSE |
|---|---|
| AXV | X.00 V |
| MX | X.00 V |

2.5.12.5 Using 8, 9 or 10 in place of X, enter the following 2 commands and check response as in 2.5.12.4

| COMMAND | RESPONSE |
|---|---|
| DXV | dX.0 V |
| MX | dX.0 V |

2.5.12.6 Using any number between 1 and 10 inclusive in place of X enter the following command and check the response.

| COMMAND | RESPONSE |
|---|---|
| RX | 1.000 KHz<br>mem rem (For X = 1 to 7)<br>X.00 V<br>OR<br>1.000 KHz<br>mem rem (For X = 8 to 10)<br>dX.0 V |

2.5.12.7 Enter any 2 of the following commands and check the MONITOR display (xxx denotes numbers).

| COMMAND | MONITOR DISPLAY |
|---|---|
| F | F xxx Hz or KHz |
| A | A xxx mV or V |
| I | I xxx V REF |
| P | P xxx µs or ms |
| D) | T 4.25 V |
| V) | or D xxx V |
| ) | V xxx V |

2.5.13.8 Type U (RETURN) and wait for display to return to normal.

2.5.13.9 On oscillator front panel, press in sequence the following buttons:

PAGE (N)
FREQ NORM (3)
PAGE (N)

(This will set PAGE 3 operation).

2.5.13.10 Type L (RETURN).

2.5.13.11 Enter the following commands in order and check the display:

| COMMAND | DISPLAY |
|---|---|
| K | 10-4 |
| N | corr |
| E | Uncr |
| O | ---- |

2.5.13.12 Enter one of the following commands and check the display:

| COMMAND | DISPLAY |
|---|---|
| I 0.224 V REF | 50 |
| I 0.7745 V REF | 600 |
| I 1.095 V REF | 1.199k |

2.5.13.13 TYPE U (RETURN).

2.5.13.14 Disconnect IEEE cable from oscillator.

### 2.5.14 RS-232 Functional Check

2.5.14.1 Connect RS-232 cable to oscillator.

2.5.14.2 Switch on VDU.

2.5.14.3 Using VDU keyboard and screen instead of computer keyboard and monitor repeat items 10.1 to 10.12 and where possible use different commands to those already checked.

2.5.14.4 Type V2V (RETURN).

2.5.14.5 Connect oscilloscope to AUX O/P.

2.5.14.6 Check AUX O/P is 2 volts peak.

2.5.14.7 Type T (RETURN).

2.5.14.8 Check AUX O/P is now between 4 and 4.5 volts peak.

2.5.14.9 Disconnect oscilloscope from AUX O/P.

2.5.14.10 Type U (RETURN) and check that oscillator display is under front panel control.

2.5.14.11 Remove RS-232 cable from oscillator.

### 2.5.15 Memory Check

2.5.15.1 Select frequency range 2 and set display to approx. 200 Hz.

2.5.15.2 Press in sequence the following buttons:

PAGE (N)
FREQ (1)
PAGE (N)
DC (*)

2.5.16.3 Check that frequency pot changes frequency by approx. +/-10 Hz (+/-5%).

2.5.16.4 Press TTL (.).

2.5.16.5 Check that frequency pot changes frequency over complete range.

2.5.16.6 Set display to any frequency in any range.

2.5.16.7 Set amplitude to any amplitude in any range.

2.5.16.8 Note display readings.

2.5.16.9 Press any button (1) to (9) and see that the display "blinks". Remember button number.

2.4.16.10 Press PAGE (0).

2.5.16.11 Alter both readings on the display.

2.5.16.12 Press in sequence the following buttons:

PAGE (N)
PERIOD (2)
PAGE (N)
BUTTON PRESSED IN STEP 2.5.16.9

2.5.16.13 Check that display is as noted in step 2.5.16.8 and mem annunciator is lit.

## 2.5.17 Completion

2.5.17.1 Switch off oscillator at front panel.

2.5.17.2 Disconnect oscillator from line outlet.

## 3.1 INTRODUCTION

3.1.1 This section of the manual "talks one through" the operation of the LDO, covering all the functions of the keys. Ideally, the LDO should be in front of the operator so that each step can be followed and the results observed.

## 3.2 CONTROLS

### 3.2.1 Introduction

3.2.1.1 Refer to Figure 3.1 showing the LDO's front panel. The push button controls can be functionally divided into two groups:

a. Those beneath and to the right of the display that have only a single function

b. Those to the left of the display, in a 3 by 4 array, that have multiple functions according to the selected PAGE

3.2.1.2 A PAGING system has been adopted in order to simplify access to extra functions without having a complex front panel. The two keys marked (0) and (N), below "PAGE", effect page selection.

3.2.1.2.1 PAGE (0) is the basic oscillator, and provides the functions indicated over the keys marked 0-9,.,*.

3.2.1.2.2 Range keys give a coarse setting of amplitude and frequency. Two rotary controls allow fine adjustment of frequency and amplitude within each range.

3.2.1.2.3 The PAGE-dependent buttons fall into three general groups:

1. Those that modify the display, but do not control outputs
2. Those that control outputs
3. Those that alter the function of the frequency rotary control

In the first group:

FREQ, PERIOD, FREQ NORM modify the upper 4 digits of the display.

VOLTS, dBm, dB REL modify the lower 4 digits of the display.

REF is used with FREQ NORM and dB REL.

In the second group:

TTL, VAR, and DC control the AUXiliary output.

In the third group:

COARSE and FINE affect the action of the frequency rotary control.

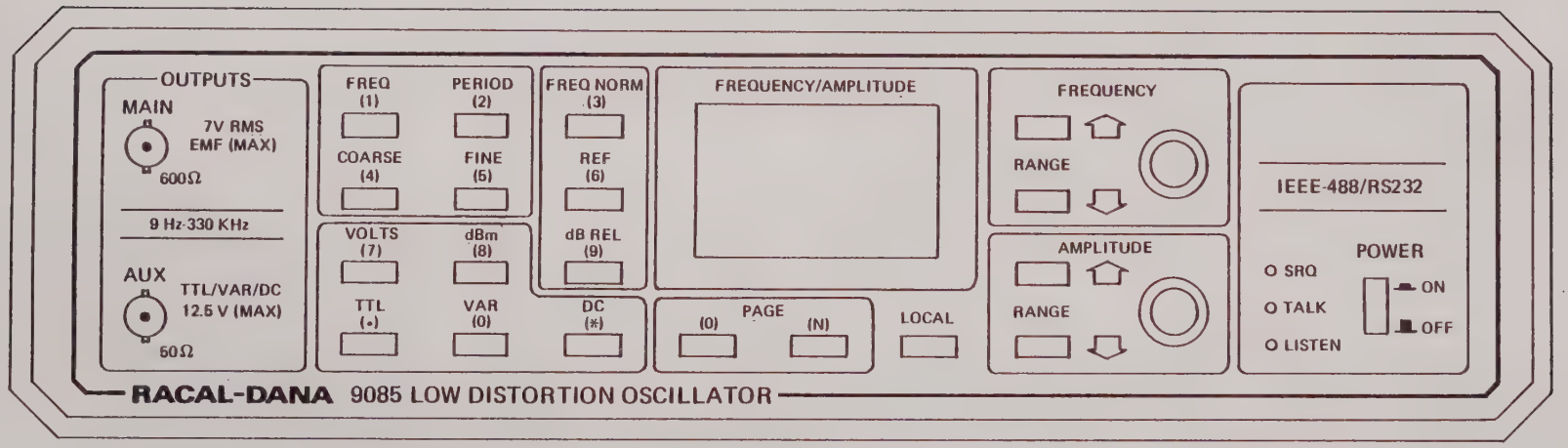



*Figure 3.1 - Front Panel, LDO 9085*

### 3.2.2 Single Function Keys

3.2.2.1 PAGE (0)

3.2.2.1.1 This key returns the oscillator to PAGE 0 operation, except when remote programming has locked-out all front panel functions. Operating the PAGE 0 key provides quick access to the standard oscillator functions from any other page.

3.2.2.2 PAGE (N)

3.2.2.2.1 This key accesses other function pages, allowing the user to find the current active page. The first press of the button shows the current active page on the display in the form P = XX where XX is the page number. The page number can now be changed using the keys marked (0) to (4). A second press of this key will set operation in the PAGE number displayed after selection. Pressing the page key twice then, without touching any others, displays the current active page without altering it.

3.2.2.3 LOCAL

3.2.2.3.1 When the oscillator is being used remotely from either the IEEE-488 or RS-232 ports, the REM annunciator is displayed. In only this condition will the LOCAL button on the front panel operate. Pressing the LOCAL button will cause a momentary display of the IEEE-488 bus address, turn off the REM annunciator, and return the oscillator to front panel control.

NOTE

The LOCAL key will be disabled if the oscillator has been issued a local lock-out command.

3.2.2.4 RANGE

3.2.2.4.1 These keys allow selection of the operating ranges for amplitude and frequency. Operation of the amplitude range keys will increase or decrease the sinewave output level in 10dB steps. Coarse frequency ranges are selected by the upper pair of keys. With the exception of the lowest, the frequency ranges are related to one another in a 3.16:1 ratio. Thus, when operating in the top 7 frequency ranges, the frequency is changed by a ratio of 10 for 2 operations of the same range key.

### 3.2.3 Multifunction Keys in PAGE 0

#### 3.2.3.1 FREQ(1)

3.2.3.1.1 Causes the upper display digits to show the oscillator frequency, in Hz or kHz, as indicated by an annunciator to the right of the display.

#### 3.2.3.2 PERIOD(2)

3.2.3.2.1 Causes the upper display digits to show the oscillator output period in ms or us, as indicated by an annunciator to the right of the display.

#### 3.2.3.3 FREQ NORM(3)

3.2.3.3.1 Sets the frequency reading to 1.000 and turns on the NHz annunciator. The frequency at the time of operating this key is taken as a reference. Changes in frequency are then shown as a ratio to the reference frequency. The relationship is:

$$\text{FREQ NORM} = \frac{\text{Oscillator operating frequency}}{\text{reference frequency}}$$

3.2.3.3.2 The display shows the normalized frequency. This function is useful in interpreting the data from standard filter tables.

#### 3.2.3.4 VOLTS(7)

3.2.3.4.1 Causes the lower 4 digits of the display to show the sinewave output as an absolute value in volts or millivolts rms.

#### 3.2.3.5 dBm(8)

3.2.3.5.1 Causes the lower 4 digits of the display to show the sinewave output in terms of the voltage required to produce 1mW into a reference impedance. The reference impedance is selected by a PAGE 3 function. PAGE 3 operation is covered in Section 3.2.6.

The displayed output is given by:

$$20 * \log \left[ \frac{\text{output voltage}}{\left[ 10 \times \text{ref.impedance} \right]^{-3}} \right]^{-\frac{1}{2}} \text{dB}$$

3.2.3.6 dB REL(9)

3.2.3.6.1 Causes the display to show 0.0 dB and to show any changes in output voltage as a logarithmic ratio referenced to the display voltage at the time of operating the key. The display will show:

$$20 * \log \left[ \frac{\text{output voltage}}{\text{reference voltage}} \right] \quad \text{dB}$$

3.2.3.7 TTL(.)

3.2.3.7.1 Sets the auxiliary output to a fixed 4.25-volt peak, TTL-compatible, rectangular pulse. The mark-space ratio is 1:3, with the rising edge coinciding with the rising zero-crossing of the main output, and the falling edge coinciding with the positive peak of the main output.

3.2.3.8 VAR(0)

3.2.3.8.1 Allows the front-panel rotary control to vary the auxiliary output from 0.1 to 12 volts peak. The level is displayed, using the last 3 digits of the lower display. The first digit displays the prompt "U".

3.2.3.9 DC(*)

3.2.3.9.1 Allows the amplitude rotary control to set a DC level from the auxiliary output from 0.1 volt to 12 volts maximum. The lower 4 digits are used to display the output level starting with the prompt "d" in the first digit position.

3.2.3.10 FINE(5)

3.2.3.10.1 Reduces the range of the rotary frequency control to approximately +/-5% of the frequency displayed when operated. If the frequency is within 5% of either extreme of the range, then the frequency control will provide 10% of the adjustment from the appropriate extreme limit. The rotational law of the frequency control is approximately logarithmic. Therefore the center frequency does not coincide with the mechanical center of rotation.

3.2.3.11 COARSE(4)

3.2.3.11.1 Returns the frequency rotary control to normal operation, after having used the FINE key.

3.2.3.12 REF(6)

3.2.3.12.1 Allows a momentary display of the reference levels and frequency when the FREQ NORM and dB REL functions have been selected. If either of these functions is inactive, the key has no effect on the corresponding display.

### 3.2.4 PAGE 1 Operations

3.2.4.1 This page is used for storing the status of the oscillator. The status consists of the conditions set from PAGE 0 and PAGE 3. Ten status settings can be stored. PAGE 0 must be used to set display and output modes. In PAGE 1, the multifunction keys (0-9) become store locations. The frequency and amplitude rotary controls and range keys, operate as in PAGE 0. Pressing any of the multifunction keys will store the oscillator's status, overwriting any previously recorded conditions. To allow the frequency to be easily set, the PAGE 0 functions of frequency COARSE and FINE are available using keys TTL(.) and DC(*), respectively.

### 3.2.5 PAGE 2 Operations

3.2.5.1 PAGE 2 is used to recall the instrument status, stored in the ten memory locations described in paragraph 3.2.4.1. The frequency and amplitude rotary controls and range keys will be inoperative.

### 3.2.6 PAGE 3 Operations

3.2.6.1 PAGE 3 has two distinct functions:

1. Informs the oscillator what reference is to be used in calculating the dBm display mode selected in PAGE 0

2. Describes to the oscillator the loading conditions of the sinewave output

3.2.6.2 The display voltage is calculated from the EMF and specified loading conditions. The oscillator does not directly measure the output voltage, but from its own source impedance, open-circuit voltage, EMF, and the loading conditions, it can calculate the loaded output voltage.

3.2.6.3 In order to avoid unnecessary complexity, it is assumed that only a limited number of loading conditions will be used when a true display of output voltage is required. The following reference impedances are available:

50, 75, 93, 100, 150, 200, 600, and 1200 ohms

3.2.6.4 There are 4 loading condition configurations that can be specified:

1. Open Circuit

2. 10 k ohms

3. Uncorrected: Operation into the reference impedance alone.

4. Corrected: The 600-ohm output has parallel or series resistance added so that the combined impedance is equal to the reference impedance. The Output is then operated into the reference impedance.

3.2.6.5 The upper 4 digits of the display show the reference impedance. The lower 4 digits indicate the loading conditions.

### 3.2.7 PAGE 4 Operations

3.2.7.1 PAGE 4 causes the LDO to calibrate its frequency ranges. See Subsection 3.8.1.

The keyboard functions and displays are as follows:

Select Reference Impedance on Upper Display

| Key | Function | Display |
|---|---|---|
| 1 | 50 | 50 |
| 2 | 75 | 75 |
| 3 | 93 | 93 |
| 4 | 100 | 100 |
| 5 | 150 | 150 |
| 6 | 200 | 200 |
| 7 | 600 | 600 |
| 8 | 1200 | 1200 |

Select Loading Conditions on Lower Display

| Key | Function | Display |
|---|---|---|
| 9 | cond. 1 | ---- |
| . | " 2 | 10-4 |
| 0 | " 3 | uncr |
| * | " 4 | corr |

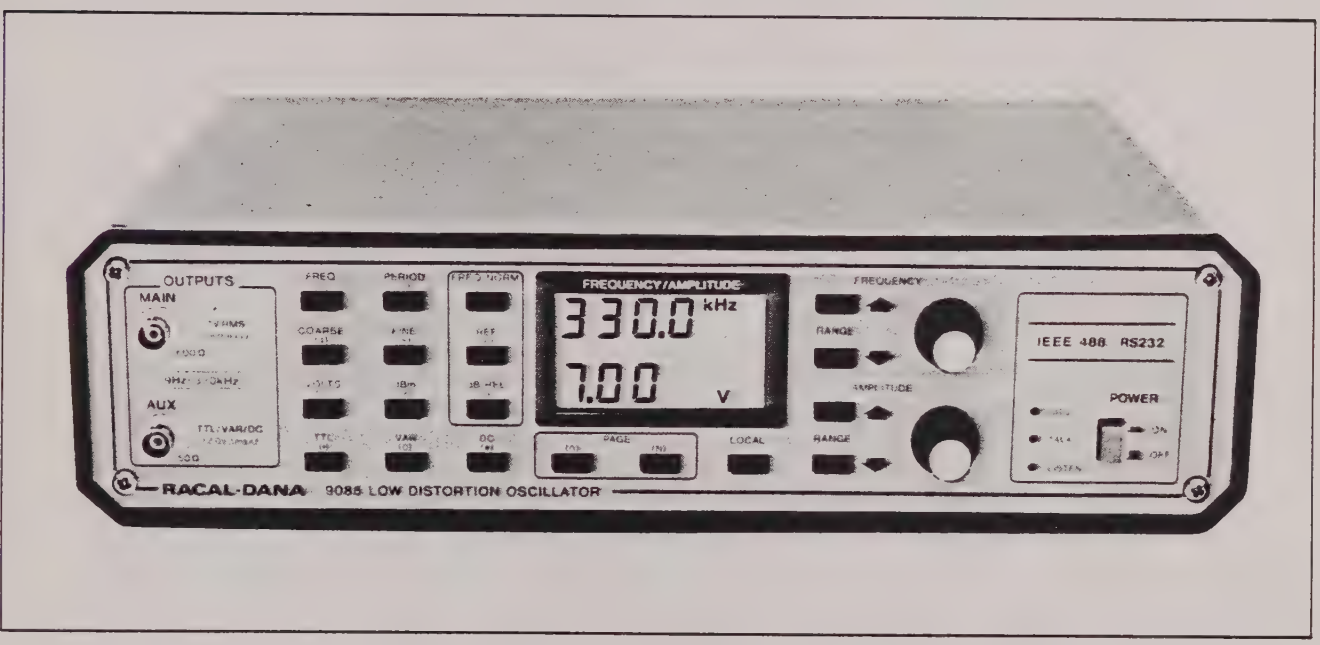



*Figure 3.2 - Front Panel Display, LDO 9805*

## 3.3 LDO CONNECTIONS

3.3.1 After reading Section 2.4 of this manual, connect the LDO to a suitable AC line outlet and switch the instrument ON by depressing the red push button on the extreme right-hand side of the front panel.

3.3.2 Connect the two inputs of a dual-trace oscilloscope to the MAIN and AUXILIARY outputs. (see Section 3.9 for use of these outputs.)

## 3.4 PAGE 0 OPERATION

3.4.1 Initially the LDO will turn the whole display on for a period of one second. One can check the display against that shown in Figure 3.2 of this Manual.

### 3.4.2 Range Keys and Rotary Controls

3.4.2.1 Set the oscilloscope amplitude sensitivities to 1V per division, and the timebase speed to 100 ms per division. Observe that the AUXILIARY output is a rectangular waveform between 4 and 5 divisions high. Note that its baseline is at zero volts so that one can use it for directly triggering digital circuits. The operating frequency is at the oscillator's lowest range, between 9 and 110 Hz. The upper 4 display digits indicate precisely the frequency. Press the upper Frequency Range key. The operating frequency moves into the next operating range. Operate the upper range key twice again and the range is 0.95 to 3.32 kHz. Set the oscilloscope speed to view a few cycles. If you are wondering where the MAIN output is - it's there, but outside the viewing resolution of the oscilloscope. The precise level is indicated on the lower 4 display digits and will be between 0.6 and 2.2 mV. In the same way as for frequency range, use the upper Amplitude Range key to bring the MAIN output level to between 1 and 2 divisions high on the oscilloscope display.

3.4.2.2 Turn the rotary controls, and ensure fine control over the amplitude and frequency as in a conventional, all analog, instrument. Turn them rapidly. Observe the tendency of the parameter being controlled to move in steps, a reminder that between the user and analog circuits there is a microprocessor.

### 3.4.3 Coarse and Fine Keys

3.4.3.1 Try setting the frequency display to exactly 1 kHz. If it is difficult, make it easier by operating the FINE key to the left of the display when within 30 or 40 Hz of 1 kHz. Now turning the frequency control allows precise setting. Turn the control from end-to-end and note that the control span has been limited to about 100 Hz. To return to the full control range, press the COARSE key. When changing control between these two keys, the display and output will change frequency depending upon the effect of the rotary control in each mode. One may also notice that the numerical center of an operating range does not occur in the mechanical center of rotation. This is because the potentiometer uses a logarithmic control law.

### 3.4.4 FREQ, PERIOD, FREQ NORM AND REF Keys

3.4.4.1 So far, only keys that directly or indirectly affect the output have been covered. The keys described in this and the following two sections only change the way in which the display shows what the outputs are doing.

3.4.4.2 Set the frequency to 2.000 kHz. Operate the PERIOD key and the display will show 500 microseconds, the reciprocal of the frequency. Note that one can still use the FREQUENCY RANGE keys, and the rotary control in FINE and COARSE modes as before. Press the FREQ key and the display returns to frequency in Hz.

3.4.4.3 Observe the effect of pressing the FREQ NORM key. Note that whenever this key is pressed, the upper display sets itself to 1.000 regardless of where the rotary control is set or which range has been selected. Thus, any frequency in the LDO's operating range can be set as a reference. After setting the frequency display to 1.000, turn the frequency control or change the range. In each case, the display shows the operating frequency as a ratio to the reference. If the reference is forgotten, press the REF key and the upper display will show it for approximately one second. The FREQ NORM operation is useful when making frequency response measurements. In many applications, especially that of filters, the characteristics are independent of the absolute frequency and can be plotted against an arbitrary reference. That reference may be a 3 dB point in the case of a low-pass or high-pass filter, or the center frequency of a bandpass filter. If it's within the operating range of the LDO, the FREQ NORM key can make it the reference, and make many measurement tasks much easier.

### 3.4.5 VOLTS, dBm, dB REL and REF Keys

3.4.5.1 These keys permit one to choose the way in which the MAIN output level is displayed. At power-on, the instrument sets itself to VOLTS. Selecting dBm and dB REL, however, provides a logarithmic display with a choice of reference voltages.

3.4.5.2 The dBm key uses a reference voltage derived from a standard operating system impedance. This impedance is selected using the Paging function described in 3.4.8 and 3.7.1. When the instrument is first powered-on, the reference impedance is 600 ohms. In this case the reference voltage for 0dBm is 775 millivolts. The reference voltage is the level required to dissipate 1 mW into the reference impedance.

3.4.5.3 The dB REL key permits one to set any voltage level inside the operating range of the LDO as a reference. Operate the dB REL key, and regardless of the output level, the lower display will show:

0.0 dB

3.4.5.4 Use the AMPLITUDE RANGE keys, and observe that the display increments up or down in 10 dB steps. The rotary control gives fine adjustment. Again, the REF key can be used to show what the voltage was when the dB REL key was operated.

### 3.4.6 TTL, VAR, DC Keys

3.4.6.1 These keys affect the levels at both the MAIN and AUX outputs. First, let's examine what happens to the MAIN output when the VAR and DC keys are used.

3.4.6.2 Operate the TTL key. Note that the LDO display confirms operation by briefly showing: ttl

3.4.6.3 Set the amplitude range to provide a reasonably sized oscilloscope display. Turn the amplitude rotary control to give minimum amplitude within the range.

3.4.6.4 Press the VAR key. The display shows briefly: var

3.4.6.5 Note that the amplitude of the MAIN output has remained unchanged. Turn the amplitude rotary control. Note that it has no effect upon the MAIN output. The amplitude of the MAIN output is at the lowest voltage of the present range. The RANGE keys are still operative; they can be used to alter the MAIN output amplitude in 10 dB steps.

3.4.6.6 By now one has noticed that the amplitude rotary control is altering the output from the AUX output. To remind one of the mode of operation, the display is now showing a "U" in the first digit position of the lower display. The rotary control varies the amplitude of the rectangular pulse from the AUX output between 0 and 12 volts.

3.4.6.7 Operate the DC key. The display briefly shows: dC

Note that the first digit of the lower display is now "d". The AUX output now provides DC voltage set by the amplitude rotary control.

### 3.4.7 LOCAL Key

This key concerns the computer interface via the RS-232 and IEEE-488 ports. When the LDO is operated remotely through these ports, the REM LCD will light and all front panel functions except LOCAL cease to operate. Providing the local lockout instruction has not been sent, the LOCAL key can be used to regain front-panel control. The key also serves as a means of displaying the IEEE-488 address set by the rear-panel switches. Each time the key is operated, it performs the command to regain local control and then displays:

Addr
=XX where XX is the address.

### 3.4.8 PAGE Keys, (0) and (N)

3.4.8.1 Now it's time to move out of PAGE 0 operations. Press the FREQ, COARSE, VOLTS, and TTL keys to return the instrument to its basic state. When one goes to another page of operation, the functions of the 3X4 keypad will change.

3.4.8.2 Press the PAGE (N) key. The lower display now shows:

P= 0

3.4.8.3 This is the current active page. Now press any key in the 3X4 keypad in the range (0) to (4). One notes that the number displayed on the lower display can be changed. This is how one sets the new page number that is desired. Set the page number to 3 and press the (N) key again. The LDO is now operating in PAGE 3 and should be displaying:

600
---

3.4.8.4 If some other message is shown, it means that the LDO has already been set to some other loading condition.

3.4.8.5 The first operation of the (N) key then always displays the current active page. The second will cause functioning of the instrument to pass to the displayed page number. If one wants to see what page is current, without leaving it, just press the PAGE (N) key twice.

3.4.8.6 Assuming that the instrument is left in PAGE 3, how does one return to PAGE 0? One could use the (N) key: press it once, enter "0", and press it again; taking three operations. Because PAGE 0 is so important, a quick way is provided to return to PAGE 0 from any other page. This is achieved by using the PAGE (0) key, the equivalent of the sequence of three key presses described above.

## 3.5 PAGE 1 OPERATION

### 3.5.1 PAGE 1 - Memory Store

3.5.1.1 Use the PAGE (N) key to set the LDO into PAGE 1 operation. One will find that the frequency and amplitude keys/controls still function as in PAGE 0. However, keys (0 to 9) now provide control of ten storage locations. Press one of these and see the display blink, confirming key operation and resulting storage. Try entering some conveniently associated parameters into the first few memories. For example, 1 kHz and 1 volt into memory 1, 2 kHz and 2 volts into memory 2, etc.

**SPECIAL NOTE**

The storing of settings will overwrite previously stored data. The FINE frequency control (available in PAGE 0) is also available in PAGE 1 operation. COARSE and FINE functions have been moved to the "." and "*" keys, respectively. This avoids conflict with memory store keys 0-9.

## 3.6 PAGE 2 OPERATION

### 3.6.1 PAGE 2 - Memory Recall

3.6.1.1 Use the PAGE (N) key to go to PAGE 2. The keys (0 to 9) can be used to recall the settings assigned to them. This page demonstrates the power of the PAGING system compared to one using a "shift" key. The settings stored under PAGE 1 operation can each be recalled with a single key press.

NOTE

It is not just amplitude and frequency that are stored, but the complete status of the instrument. Thus, if a setting is made using PERIOD and VAR from AUX, then that is retrieved at recall. This means that a mixture of modes can be stored, allowing great flexibility in setting up small test systems. For example, AUX can be set to a different DC level for every different MAIN output frequency. Feeding AUX into a series of window comparators allows it to be used as a digital control, say, for routing the MAIN output to different test points.

## 3.7 PAGE 3 OPERATION

### 3.7.1 PAGE 3 - Set Reference Impedance/Describe Output Load

3.7.1.1 PAGE 3 has two specific uses. It is important to realize that they are quite distinct.

3.7.1.2 The first function of PAGE 3 is to set the voltage reference used, when displaying output voltage in dBm. The dBm annunciator when lit indicates that the output voltage is being logarithmically related to a reference voltage which dissipates 1 milliwatt into the reference impedance. PAGE 3 gives the user a choice between the most commonly used reference impedances. Operate keys (1) to (8) and run through all of them. These impedances are shown in the upper display.

3.7.1.3 If one returns to PAGE 0, after selecting each impedance, no change in the displayed MAIN output voltage is noted. The only change is in the value shown when one has selected dBm. Also, the MAIN output impedance of 600 ohms remains the same, regardless of what reference impedance has been selected. All that has happened is that the LDO has been notified to make some of its display calculations from a different reference impedance.

3.7.1.4 The second function of PAGE 3 is to describe to the LDO the load conditions into which the MAIN output is to operate. The details of the display for each choice are to be found in Subsection 3.2.6 of this manual.

3.7.1.5 Again, describing the load conditions to the instrument makes no change in its output impedance or unloaded output voltage, only to the displayed voltage.

3.7.1.6 The first two load conditions are described. They are an infinite load impedance (in other words, an unloaded output) and 10 kilohms.

3.7.1.7 If one places a high-impedance AC voltmeter across the output and specifies operation into an infinite load impedance, then the voltmeter and LDO display would agree within the specification limits. Now use PAGE 3 to specify operation into 10 kilohms. Note that the LDO display is lower than that of the voltmeter. It is only when a 10 kilohm resistor is placed in parallel with the voltmeter, across the LDO output, that their two readings agree. A 10-kilohm load specification will often be convenient when testing and developing individual circuit blocks. In these circumstances, it will not matter what the impedance of the signal source is, though 600 ohms is a good working value. The remaining load choices are CORRected and UNCoRrected. These choices relate to keys (1) to (8) of PAGE 3.

3.7.1.8 Sometimes it is important for the source impedance of the signal to be the same as that of the load impedance. This is often so with systems containing passive components, such as transformers and inductance/capacitance filters that have critical frequency, phase, and amplitude response. Suppose the LDO is to test just such a system operating from 100 ohms. It is necessary to inform the LDO that it must allow for a 100-ohm load, but simultaneously turning its 600-ohm output impedance into 100 ohms by placing across its output (i.e. effectively in parallel with the 600-ohms internal source impedance) a 120-ohm resistor. This is the corrected (CORR) situation.

3.7.1.9 The LDO can also allow for operation into the reference impedance alone from the 600-ohm source impedance by using the UNCoRrected condition.

3.7.1.10 To convert the output impedance of the LDO for CORR operations, use the following resistors:

For 50 ohms, use 54.5 ohms in parallel with the output.

For 75 ohms, use 85.7 ohms in parallel with the output.

For 93 ohms, use 110 ohms in parallel with the output.

For 100 ohms, use 120 ohms in parallel with the output.

For 150 ohms, use 200 ohms in parallel with the output.

For 200 ohms, use 300 ohms in parallel with the output.

For 600 ohms - no additional resistor is required.

For 1200 ohms, use 600 ohms in series with the output.

## 3.8 PAGE 4 OPERATION

### 3.8.1 PAGE 4 - Frequency Calibration

3.8.1.1 As soon as one goes to this page, the LDO will commence calibrating all of its frequency ranges. It does so by using the microprocessor system-clock as a reference. The display first shows all its digits and annunciators for a brief period followed by the display:

SELF
-CAL

3.8.1.2 This display remains until calibration is complete, approximately a minute.

3.8.1.3 When should one use frequency calibration? Normally not often. It's there as protection against the normal aging effects of components. It allows one to maintain the instrument's calibration during normal use.

## 3.9 USING THE OUTPUTS

3.9.1 The three outputs: MAIN, AUXiliary, and QUADRATURE, come from the same printed circuit board, but they do not share the same grounding points. When the highest signal purity is required from the MAIN output, ensure that the only ground point used is that at the MAIN output.

3.9.2 The AUXiliary output is driven from an emitter-follower, with an active pull-down and a series resistance of 51 ohms. In TTL and AUX mode, loading the output will cause the voltage drop across the emitter-follower to be seen as a reduction in AUXiliary output. To drive TTL levels into a 50-ohm load will require using the VARiable mode. If it is known that the AUXiliary output will always be loaded with 50 ohms, then the TTL level can be reset to allow for this by selecting a new resistor value for R496.

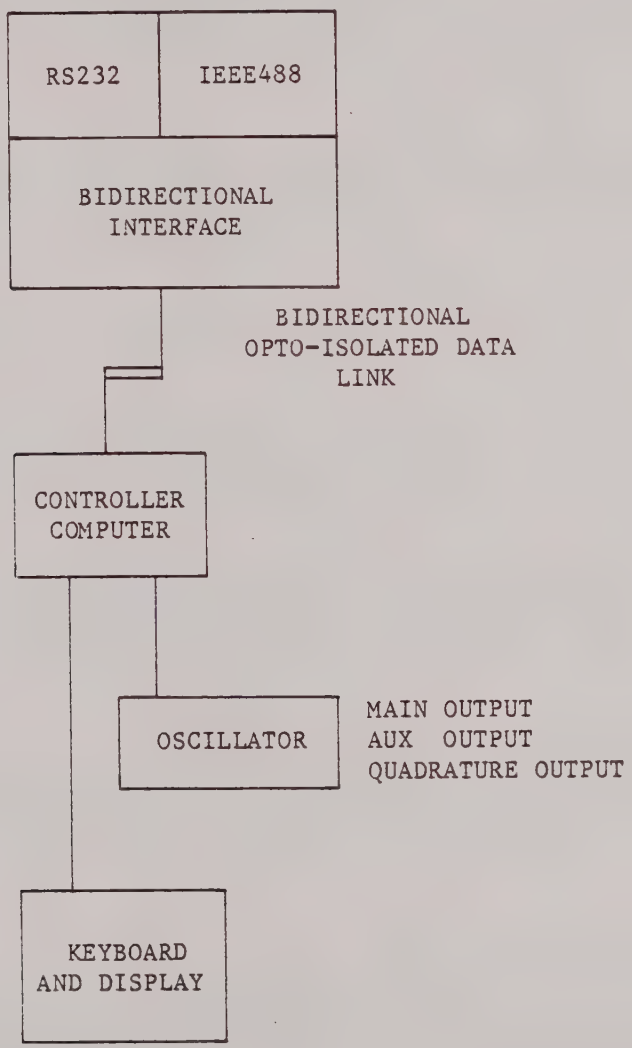
3.9.3 When the AUXiliary output is set to DC, negative feedback is taken after the drive devices and the effect of the diode drops seen in pulse output modes are eliminated.

## 3.10 INDICATION OF STABILIZED AMPLITUDE

3.10.1 The microprocessor monitors a digital output from the analog board that indicates the oscillator amplitude has not stabilized. While the condition of this output is "true", the decimal point, just in front of the "mV" annunciator, is displayed. This decimal point is not used by any other function. The speed of stabilization is related to the oscillator frequency. Above 1 kHz, it is fast enough to cause the stability indicator to light only very briefly.

## 4.1 INTRODUCTION

4.1.1 The oscillator consists of four main blocks:




4.1.2 The controller/computer accepts commands and sends data to the front-panel keyboard and display or to external devices via the RS-232/IEEE-488 interface.

4.1.3 The RS-232/IEEE-488 interface employs its own microprocessor to give a high level of sophistication to the processing of data to and from the main controller. Single-point grounding is used to reduce ground (earth) loop currents.

4.1.4 The controller/computer is described separately because it has the following control functions:

1. Monitoring the front-panel switches
2. Measuring the front-panel potentiometer positions
3. Monitoring commands from the interface
4. Outputting data to the display
5. Outputting control data to the oscillator

Plus the following computing functions:

6. Formatting data for the display
7. Calculating and using calibration constants from the SELF-CAL mode

8. Calculating and using calibration constants for the front panel potentiometers

## 4.2 AUTOCALIBRATION

4.2.1 The unit exploits the ease with which microprocessor systems can make accurate measurements of time and frequency.

4.2.2 There are two areas where calibration is made against the microprocessor's own system clock. First, for the analog-to-digital converters that read the front-panel frequency and amplitude potentiometers and second, for each of the oscillator's frequency ranges.

4.2.3 Autocalibration ensures consistent performance to specification, throughout the lifetime of the instrument, without the need of periodic recalibration and adjustment by a service engineer. While calibration is in progress, the message SELF-CAL is shown on the display.

## 4.3 ANALOG BOARD OPERATING PRINCIPLES

4.3.1 The oscillator is based upon a feedback system commonly called the Two-Integrator Loop (formed by A1, A2, A3). This forms a second order oscillatory system. The operating frequency is determined by the time constants of integrators based around A2 and A3. The coarse operating ranges are provided by switching the integration capacitors.

4.3.2 Fine frequency control uses 12-bit multiplying DACs at the input of each integrator. Amplitude is controlled by varying the feedback around A1 and A2.

**4.3.3** This oscillator configuration lends itself to providing the timing signals for a synchronous precision rectifier. The output of this rectifier is a DC signal proportional to the peak-to-peak signal at the output of A3. This is compared with a DC reference and the error signal fed back to the amplitude control, to form a closed-loop control system. A window comparator at the input of error amplifier A5 supplies a logic output to the microprocessor to indicate that the amplitude has settled to within a predetermined operating level.

**4.3.4** The timing signals provide an internal, TTL-compatible output that is sent to the microprocessor board for measurement of the oscillator frequency and period during calibration, as well as control pulses for operation of the auxiliary output.

**4.3.5** Fine control of amplitude operates by varying the DC reference that sets the level to which the oscillator stabilizes. The coarse control operates through a series of cascaded, switched attenuators. The first uses solid-state switching and is placed before the final amplifier A4. The second and third attenuators use relay switching and are designed to operate from a 600-ohm source, and present an output impedance of 600 ohms.

**4.3.6** The AUXiliary and sinewave outputs can both be varied via the 8-bit DAC. When one output is under control of this DAC, the other is operated from a fixed reference. The fixed level from the AUXiliary output is internally adjustable, but is factory preset for TTL-compatibility.

**4.3.7** When the AUXiliary output is under variable control, the sinewave output goes to a level that corresponds to the minimum of the current fine-adjustment range. Coarse attenuation using the range keys is still available.

**4.3.8** A QUADRATURE output comes directly from the internal oscillator loop via a resistive attenuator that gives an output impedance of 600 ohms and a level approximately 30dB below the sine output on the highest amplitude range. The QUADRATURE output will follow the fine level control, but will not be altered by the coarse range keys.

## 4.4 DETAILED CIRCUIT DESCRIPTIONS

### 4.4.1 Analog Board

This consists of the oscillator, level control and stabilization, output attenuators, frequency control, and initialization circuitry. The following description refers to drawing A410-088, sheets 1 and 2.

#### 4.4.1.1 Initialization

4.4.1.1.1 IC424A and IC424D together with C468 and part of RP403 set the inhibit input of IC430 'HIGH' when power is first applied to the board. This opens all transmission gates in IC434 ensuring no oscillator output. The input control gates, IC425B,C,D, for the auxiliary output are also disabled by the same signal. This inhibit function gives the microprocessor time to initialize output ports. When this task is completed, the inhibit is removed by strobing HIGH the input to TR411.

4.4.1.1.2 The oscillator frequency is determined by the time constants in the integrators formed around IC414 and IC423. The range capacitors are switched by the transmission gates IC413, IC422. Fine frequency control is achieved with the twelve-bit multiplying digital-to-analog converters IC412, IC419. The control range is increased on the lowest range by switching in transmission gates IC415C, IC415D, IC421C, IC321D. The amplitude stabilization circuit controls the signal level at the output of IC423. The signal at this point is attenuated by R434, R418, and is passed directly to IC404 and via phase inverter IC402 to IC403. Integrated circuits 403, 404, 431, 432, 408A, 408C, 405A, 405B form a precision rectifier that operates on the peak-to-peak amplitude of the signal. IC403, IC431, IC408A, IC405A form one half of the rectifier sampling the negative peaks by virtue of the inverter IC402. The remaining integrated circuits, 404, 432, 408C, 405B operate similarly but on positive peaks. It is only necessary to describe one of the two sections. IC403 and IC431 form a "follow and hold" function. C420 is the storage capacitor. IC409E has an open-collector transistor that behaves as a switch across this capacitor. During the first positive quarter cycle in any complete cycle IC409E is high impedance and C240 follows the incoming signal to IC403. At the peak of the signal, D411 will cease to conduct, leaving C420 charged to the peak voltage. During the second quarter of the cycle, the sample and hold formed by IC408A, C402 and buffer IC405A samples the stored voltage upon C420 via buffer IC431. In the third quarter of the cycle, the storage capacitor C420 is discharged by the transistor at the open collector output of IC409E. The timing signals for this process come from integrated circuits 427, 420, 426A, 426B and monostable 1 and 2 in IC417. Comparators IC427, IC420 use the quadrature relationship between the outputs of the two integrators, together with the D-type bistables of IC426 to provide a positive-going rectangular pulse during the first quarter cycle of both positive and negative excursions of the output.

4.4.1.1.3 This rectangular pulse is used to discharge the "follow and hold" capacitor of one of the peak rectifiers, while initiating a sample pulse from the monostable on its trailing edge to the other peak rectifier.

4.4.1.1.4 IC409A and IC409F are level converters between the TTL outputs of IC417 and the logic levels required by IC408 of OV and 15V.

4.4.1.1.5 The DC outputs of each half of the rectifier system are summed together at the junction of R416 and R415, and pass to the non-inverting input of IC401B. IC401B compares the output of the precision rectifier with a DC reference from the output of IC438C. It also behaves as a low-pass filter that provides the dominant stabilization pole in the amplitude control loop. To ensure maximum speed of stabilization in each frequency operating range, the time constant of this pole is switched by IC406 which is controlled in parallel with range switches IC413 and IC422.

4.4.1.1.6 The output of IC401 controls the gain of the transconductance amplifiers IC407A and B. IC401A is a phase inverter and IC400 a transistor array that level shifts the control voltages that swing either side of OV to control currents referred to the -15 volt rail required by IC407. IC400 generates control signals for IC407A and B in such a way that the two transconductance amplifiers are not operative at the same time. When IC407B is operating, negative feedback is produced that reduces the amplitude of oscillation. When IC407A operates, positive feedback is produced and increases the amplitude of oscilation. Ideally, when the oscillator amplitude is stable, IC407A and B would be nonconducting, but positive and negative feedback is required throughout the oscillator's operating range to compensate for circuit layout and component losses.

4.4.1.1.7 The reference voltage from the output of IC438C is derived from the band-gap voltage reference D412 and the 8-bit DAC IC433. The output of DAC IC433 is buffered and amplified by IC438A and by taking a proportion of this voltage and the reference voltage directly and summing them at the input of IC438D, a control voltage is derived for the required upper and lower limits of the fine amplitude control range. These upper and lower limits can be adjusted and are preset at the time of manufacture. The lower limit is set by SOT (select-on-test) resistors R513 and R544. The upper limit is set by SOT resistors R511 and R512. If the adjustments are made on the lower limit first, with the ZN429 output set to zero, they are not interactive. When the auxiliary output is required to be variable, the output of DAC IC433 is removed from control of the oscillator amplitude by the opening of switch IC439A and B. The control voltage is determined by the lower limit setting alone.

4.4.1.1.8 The auxiliary output is made up of variable DC source IC437A, switch TR402, and emitter-follower buffer TR405. When transmission gate switch IC436 is open, pulses from IC426 turn TR402 ON and OFF at the oscillator frequency. The amplitude of the rectangular pulse produced at the collector of TR402 is controlled by varying the output level from IC437A. The input to IC437A is derived from one of two sources. For TTL-level Auxiliary output, IC436D is open and IC436C is closed. The input to IC437A is set by potential divider R496 and R493 across the reference D412. When variable auxiliary output is required, IC436D closes, IC436C opens, and the DAC-controlled output of IC438A feeds the input to IC437A. Select-on-test resistors R483 and R480 set the full-scale output voltage in variable output mode. Output drive capability is ensured by using emitter-follower TR402 to pull-down via D410. This system ensures adequate drive into capacitive loads. The effect of diode drops in the VBE junction of TR405 and D410 are bypassed by R482. This leads to some rounding of the top and bottom of leading and trailing edges, but gives compatibility between drive requirement of TTL and 5 V CMOS. IC416 connects C481 across the output of IC437 to maintain a low impedance at high frequencies at this point. When a DC auxiliary output is selected, C481 is disconnected. Transmission gates IC416 A and C move the feedback point from before to after the emitter-follower output stage. This removes the effects of varying VBE-drop with load. The output impedance is determined by R484.

4.4.1.1.9 The output buffer amplifier IC435 is preceded by a CMOS switch system that has three positions, 0dB, - 10dB, and OFF. A 0, 10dB attenuator is provided by CMOS switches in IC429, IC434 selecting a signal path through either R472 or R473 to the input of IC435. The path through R473 provides 10 dB less output than that through R472. The unused path is grounded. Transmission gates are paired to reduce the effects of their ON resistance.

4.4.1.1.10 Following IC435 there are two cascaded attenuators giving 20 dB and 40 dB attenuation. These are designed to be operated from a 600-ohm source and have an output impedance of 600 ohms. The output of IC435 is padded to 600 ohms with R500. The impedance at the main output is 600 ohms,regardless of attenuation. The attenuator networks are switched in and out using relays RLY400 and RLY401. These latching relays have their operating coils driven by TR407 to TR410.

4.4.1.1.11 IC430 decodes the control from the microprocessor board and level shifts to + and - 7.5 volts. Input buffers IC428E and IC428F have open collector outputs and perform a level shift from TTL to 0,+7.5V required by IC430. When the board is first powered, the INH input of IC430 is held high. This causes all of the switches in IC434 to be OFF, ensuring that no signal can pass to the input of IC435.

4.4.1.1.12 IC437C and IC437D form a window comparator that compares the output of the precision rectifier and the amplitude reference voltage. Provided the two are within a range determined by potential dividers R522, R527, R528 and R523, the outputs of IC437D and IC437C will be low.

The window is set at approximately plus and minus 45mV. Normally the window comparator will not provide a positive output. This will only occur briefly while the amplitude is settling as a result of range switching or amplitude changes. Outputs from the window comparator and initialization circuit are summed together at the base of TR406. If the initialization circuit has failed to reset or the amplitude failed to stabilize to the correct value, the condition will be flagged back to the processor with a low voltage at the collector of TR510.

### 4.4.2 Microprocessor and Peripheral Interface

Drawing A410-087, sheet 1 shows the microprocessor system. This comprises a 6502 microprocessor running at 1 MHz, with 16K of program in two 8K EPROMS, IC106 and IC105. IC104 provides operating RAM and is normally fitted with battery-backed memory. The software is capable of detecting whether volatile or non-volatile memory is present. When volatile memory is fitted, the microprocessor clears all memory storage locations, and performs a calibration. With non-volatile memory, the microprocessor performs basic initialization, displays all segments of the LCD, and passes almost immediately to PAGE 0 operation. Interfacing is achieved with the 6821 and 6522, IC101 and IC102, as described in Section 4.4.3. All the devices on the microprocessor bus are memory-mapped; decoding is performed by IC108.

### 4.4.3. Digital Interface

4.4.3.1 Interfacing to the microprocessor bus is performed by a 6522 and 6821 (see Drawing A410-087, sheet 2). Port A of the 6821 provides a 4-bit bus from which a number of CD4042 latches receive data.

4.4.3.2 IC117 directs the data latch strobe pulse from CA2 to the required latch in accordance with the address set upon PA4, PA5, and PA6 of IC102.

4.4.3.3 The 6522, IC101, has internal counter time capabilities that are used for autocalibration and performing front panel potentiometer position measurement. PB6 is set by firmwave to count incoming pulses.

4.4.3.4 Transmission gates IC118A and IC118B select as input either the 1MHz system clock or a TTL output from the analog oscillator board, synchronous with the frequency of oscillation.

4.4.3.5 IC119 divides the frequency of signals to be measured by four. It also gates these signals ON and OFF in accordance with the status of reset inputs R. With this system, there are the facilities to count a number of cycles from the oscillator for the gate period set by the status of R input to IC119 or to measure the period of a signal by using IC119 to pass 1MHz system clock pulses, when IC118B is ON.

4.4.3.6 Both modes of operation are used in order to calibrate the oscillator over the entire operating frequency range. The latter facility of counting system clock pulses (divided by four) is used in the position measurement of the potentiometers. IC125 is a dual 555 timer with one half devoted to each potentiometer.

4.4.3.7 The potentiometer is used to vary the current available to charge capacitors C127 or C128. The microprocessor can trigger the timer, allowing the capacitor to charge at a rate determined by the potentiometer position.

4.4.3.8 During the charging period, IC119 will be enabled via IC121A, IC121B and either IC123C or IC124C depending upon the potentiometer under measurement. When the timing capacitor reaches the voltage at the VC input, IC119 will be disabled and the counter in IC101 will have accumulated a value dependent upon the charging time of the capacitor C127 or C128 and, hence, upon the position of the potentiometer.

4.4.3.9 To allow for component tolerances, the potentiometer measurement circuits are calibrated when the oscillator is initially powered. This is performed with the transmission gate system IC123, IC124-sections A,B and D of each. After calibration, switches B are closed and the others open. This connects the wiper track through to the IC125 measurement system. At calibration, transmission gates A and D are used to make measurements at each end of the potentiometer. This approximates a measurement with the potentiometer set at its maximum and minimum position.

4.4.3.10 A serial data link with handshake is provided by PB0, PB2, CB1, and CB2. Data passes in and out under the control of externally generated clock pulses. IC120A synchronizes the edges of the external clock with phase 2 of the system clock.

### 4.4.4 Power Supply and Reset Circuit

4.4.4.1 Refer to drawing A410-087, sheet 3. Monolithic regulators provide +15, -15, and 5V. System reset is provided by IC129, TR100 and TR101. IC129 provides, in effect, a dual comparator with a defined wide hysteresis. C126 and R140 provide the reset time constant. When C126 is discharged, the output from pin 5 of IC129 is high. TR101 conducts and the RESET line is held low in its active state. When C126 is allowed to charge through R140, the potential across it reaches that required to operate the upper comparator with input at pin 2. TR101 is turned off, the RESET line goes high, and the microprocessor begins to run. C126 is held low by a second comparator system that looks at the incoming voltage to the 5V regulator IC127. If this voltage drops below 7 volts, C126 is discharged by TR100 and the RESET line is pulled low.

4.4.4.2 This system ensures that the microprocessor is never allowed to run at a reduced supply voltage that could corrupt memory.

4.4.4.3 The IEEE-488 interface is powered separately from the main oscillator from an additional secondary winding on the AC power transformer. This enables a single-point grounding (earth) system.

### 4.4.5 Front Panel Circuit Functions

4.4.5.1 The front panel schematic is shown in Drawing A410-091. It can be divided into three main functional areas:

1. The Keyboard
2. The Display
3. Potentiometer and IEEE interface status LEDs.

4.4.5.2 The Keyboard

4.4.5.2.1 The keyboard status is interrogated from firmwave via the 6522 and 6821 ports, IC101 and IC102. The technique used is a simple matrix encoded system. Switches S300 - S315 and S316 - S318 are dealt with as two separate groups.

4.4.5.2.2 Taking Group S300 - S315. In the quiescent state, PB0-3 are set to low level outputs; PB4-7 are set to inputs. Thus all inputs to IC300A are pulled high by R300 - R303, and the output from IC300A to input CB1 of the 6821 will be at 0V.

4.4.5.2.3 Pressing any of the switches in the Group S300 - S315 will connect one of the inputs to IC300A to a low level on PB0-3. The output of IC300A will go high. The input transition to CA1 causes an internal flag within IC102 to be set. This is polled by the microprocessor. When the flag indicates a key is operated, the microprocessor reads PB4-7 of IC102 to find which column of the matrix contains the operated key. It then writes zeros to PB4-7 and reads them in from PB0-3 to find which row contains the operated key.

4.4.5.2.4 Keys S316 - S318 are read by a simplified system like that above. PB3 - PB5 of IC101 are configured as inputs. Pressing any switch of S316 - S318 will cause the output of IC300B to go high, signalling the processor, in a way similar to CA1, that a key is being operated. The microprocessor then reads PB3 - PB5 of IC101 to find which key has been operated.

4.4.5.3 The Display

4.4.5.3.1 The liquid crystal display is driven from dedicated controller IC301. This receives data from the microprocessor via a serial interface.

4.4.5.3.2 Data is shifted in on SI, 8-bits at a time under control of an externally generated clock input on SCK. The C/D line indicates whether the information is to be interpreted as commands or data.

4.4.5.3.3 The BUSY line controls the acceptance of data. R318 and C303 are used to pull the reset input low at power-up.

4.4.5.4 Potentiometer and IEEE-Interface LEDs

4.4.5.4.1 These portions of the PCB are isolated to avoid current loops.

### 4.4.6 RS-232/IEEE-488

#### 4.4.6.1 Interface Ports

4.4.6.1.1 Communication between the two boards takes place via an optically-coupled serial data link that enables a single-point grounding (earth) system to be used.

4.4.6.1.2 The interface is microprocessor-based, using a 6502 microprocessor with a 2764 EPROM storing the program and 2K x 8 of operating RAM. The IEEE-488-bus protocol and electrical interface requirements are handled by IC203, IC204, and IC205.

4.4.6.1.3 IC209 is a serial interface adaptor handling the RS-232 port via level-shifting buffers IC212 and IC213. IC210 handles serial communication with the oscillator main board. This IC generates the clock used for the data transfer.

4.4.6.1.4 Port A, inputs 1-7 read the status of the rear-panel switch bank that sets the IEEE interface address and the start bit, stop bit and parity of the serial interface. Port B bits 2, 3, and 4 directly operate the front-panel LEDs indicating the IEEE bus status. Bit 7 output supplies the clock required by the RS-232 interface IC209.

4.4.6.1.5 The main interface devices are all memory-mapped. The address decoding is provided by IC208.

4.4.6.1.6 The power supply provides a stabilized 5V and nominal plus and minus 12V supplies for the RS-232 interface, IC212 and IC213.

4.4.6.1.7 The reset is similar to that on the oscillator controller board. It uses a dual comparator system, IC201, to monitor the incoming unregulated supply voltage and provide a delayed reset only when this voltage is above a defined minimum.

#### 4.4.6.2 Communication Requirements

4.4.6.2.1 Communications with the oscillator, via either of these ports, takes place by sending and receiving strings of ASCII characters. The format of this data is the same for both ports. Alphabetic characters can be upper or lower case.

4.4.6.2.2 Information passes back and forth as a series of messages. There may be one or more messages together in a block of information called a record. The end of a record sent to the oscillator is indicated by a CR (Carriage Return) and LF (Line Feed). Records from the oscillator are always terminated with CR and LF.

4.4.6.3 Message Format

4.4.6.3.1 Messages consist of the following sections:

1. Command Word
2. Data Field
3. Units Field

4.4.6.3.2 They are sent or received in this order, without any spaces between them. For example, take the message:

F100Hz

Here we have:
F - Command word
100 - Data field
Hz - Units field

4.4.6.3.3 The only exceptions to this format are for baud rate and Error messages where there is no applicable Units field .

4.4.6.3.4 Messages from the oscillator consist of a null string (ASCII code '0') if the oscillator has no data to send.

4.4.6.3.5 If the LDO is sent more than one message in a record, for example:

A;F;I(CR LF)

Then the reply will have more than one message. For example, the reply to the above record may be:

A1.00V(CR LF)F1.00KHZ(CR LF)I.775VREF(CR LF)(EOI)

How this reply is handled by the controller will depend upon the programming language in use. When using BASIC, an ENTER or INPUT command is used to gather data from the IEEE-488 bus. With a CONTROLLER that does not use EOI to indicate the end of a STRING, the gathering of incoming data will terminate at the receipt of the first CR LF. This results in the rest of the data being left in the oscillator's output buffer. If unused messages remain in the buffer, then confusion can arise when LDO replies do not correspond with the requests. When this buffer is empty, the LDO has no information to send and it will output a null string. This can be used as a means to verify the end of a message or group of messages.

4.4.6.4 The Command Word

4.4.6.4.1 Table 4.1 lists the acceptable command words which are described below. Each consists of a single alphabetical character in upper or lower case. If a command word is followed directly by a message separator or record terminator, then it is interpreted by the oscillator as a request for data.

4.4.6.4.2 If a command word is followed directly by a valid data field and valid units field, then it is interpreted by the oscillator as a command to alter its operation in accordance with the data.

The Commands are:

F+data+units - sets the operating frequency in accordance with with the data and units specified.

F - requests the operating frequency. The reply is of the form F+data+units.

A+data+units - sets the amplitude of the main output in accordance with the data and units specified.

A - requests the amplitude of the main output. The reply is of the form A+data+units.

I+data+VREF - sets the reference voltage used in dBm calculations, in accordance with the data field. Note that the units field is always the characters "VREF".

I - requests the reference voltage. The reply is in the form I+data+VREF.

P+data+units - sets the operating period in accordance with the data and units field.

P - requests the operating period. The reply is in the form P+data+units.

D+data+units - sets the auxiliary output to DC and the voltage defined by the data and units.

D - requests the status of the auxiliary output. The reply is in the form:

T+4.24+V - if the AUX output is in TTL
V+data+units - if the AUX output is in VAR
D+data+units - If the AUX output is in DC

V+data+units - sets the auxiliary output to VAR, at the voltage defined by the data and units.

V - requests the status of the auxiliary output, with replies the same as described for D.

T - sets the auxiliary output to TTL operation; there is no reply condition.

M+data - stores the status of the oscillator into the memory location indicated by the data field.

R+data - sets the status of the oscillator to that stored in the memory location indicated by the data field.

U - sets the oscillator to front panel control.

L - sets the oscillator to remote operation - this condition is indicated by display of the "REM" LCD.

O - defines the main output loading conditions as an open circuit.

K - defines the main output loading conditions as 10 kilohms.

N - defines the main output loading conditions so that the source impedance is CORRected to equal the reference impedance, and loaded with the reference impedance. (see Section 3.7.1)

E - defines the main output loading conditions as equal to the reference impedance with UNCoRrected source impedance (see Section 3.7.1)

C - sets the oscillator to the PAGE 4 function of self-calibration. When this is completed, operation will return to PAGE 0.

B+data - sets the RS-232 interface baud rate to that indicated in the data field. See Table 4.1, Note 2 for the permitted values.

4.4.6.5 The Data Field

4.4.6.5.1 The data field will be received in ASCII format, decimal, numbers, in one of two formats.

1. Fixed point e.g., 23.75
2. Floating point e.g., 2.375E+1.

4.4.6.5.2 'E' represents the exponent and can be in upper or lower case ASCII. The sign can be '+' or '-' e.g.:

2.375E-1 represents 0.2375 in fixed point.

The data can be expressed to a maximum of 7 significant digits. If the data field is over 7 digits, the overflow is ignored with no error routines activated, i.e.:

1. 23.756249 is taken as 23.75624
2. 2.3756249E+1 is taken as 2.375624E+1

4.4.6.6 Transmissions from the Oscillator IEEE-488/RS-232C Port

4.4.6.6.1 The data field will be transmitted in ASCII format, decimal, fixed point numbers.

4.4.6.7 The Units Field

4.4.6.7.1 Table 4.1 shows the units associated with each command. When a command is followed by data and where Units are indicated by Table 4.1, they must be added. If they are omitted, the message is ignored and an error message returned.

4.4.6.8 The Message Separator

4.4.6.8.1 If several messages are to be included in a record, they must be separated by a comma or semicolon. If a message is not terminated with a message separator or a record terminator, then the whole message up to the next valid message separator will be ignored, and an error message returned.

4.4.6.9 Interface Messages

4.4.6.9.1 The interface messages consist of commands that set and request operating conditions. Where commands or data are invalid, an error message will be returned. These error messages are defined in Table 4.3.

4.4.6.10 IEEE-488 Address Selection

4.4.6.10.1 A rear-panel switch bank is used to set the IEEE-488 port address. The five switches have two positions, 0 and 1, with binary weights from 1 to 16 giving address values from 0 to 31. The setting of this switch can be interrogated from the front panel by operating the LOCAL key.

4.4.6.11 GPIB Subsets Implemented

4.4.6.11.1 The LDO 501 IEEE-488 interface implements a subset SH1, AH1, T2, L2, SR1, RL1, DC1, DT0 of IEEE-STD-488-1978 specification.

4.4.6.11.2 See Appendix C of the standard for an explanation of these abbreviations.

4.4.6.12 Secondary Address Implementation

4.4.6.12.1 The LDO does not make any use of seconday addresses and will ignore all portions of an address other than the primary.

4.4.6.13 RS-232C Port Configuration

4.4.6.13.1 The default baud rate is 1200. This rate can be set to another value from the RS-232C port or from the IEEE-488 port. The rear-panel switch, shared with IEEE-488 address selection, can be used to set the number of data, parity, and stop bits. The settings are shown in Table 4.2. Characters are echoed back. A CR is echoed back as CR/LF.

**Table 4.1 - RS-232/IEEE-488 Commands and Data Format**

| COMMAND | FUNCTION | ALLOWANCE MAX | RANGE MIN | ALLOWABLE UNITS |
|---|---|---|---|---|
| F | Frequency | 332000 Hz | 9 Hz | kHz, Hz |
| A | Sine Amplitude | 7 V | .665 mV | mV, V |
| I | Impedance | see NOTE 1 | | VREF |
| P | Period | 3.03 µs | 111 ms | µs,ms |
| D | Aux-DC | 12 V | 0 V | mV, V |
| V | Aux-Variable | 12 V | 0 V | mV, V |
| T | Aux-TTL | - | - | - |
| M | Mem Store | 10 | 1 | - |
| R | Mem Recall | 10 | 1 | - |
| U | Manual | - | - | - |
| L | Remote | - | - | - |
| O | Open Circuit | - | - | - |
| K | 10K load | - | - | - |
| N | Corrected load | - | - | - |
| E | Uncor. load | - | - | - |
| B | Baud Rate | 9600 | 110 | see Note 2 |
| C | Auto-cal | - | - | - |

**Note 1:** The reference impedance can be in the range 50 - 1200 ohms. The data sent to the oscillator must be in the form of the reference voltage. This is given by the expression:

$$\left[\frac{R}{1000}\right]^{\frac{1}{2}}$$

where R = reference impedance in ohms.

If the impedance is requested from the oscillator, it will be transmitted in this format.

**Note 2:** Available baud rates are 110, 600, 1200, 4800, and 9600.

## Table 4.2 - RS-232 Data Format

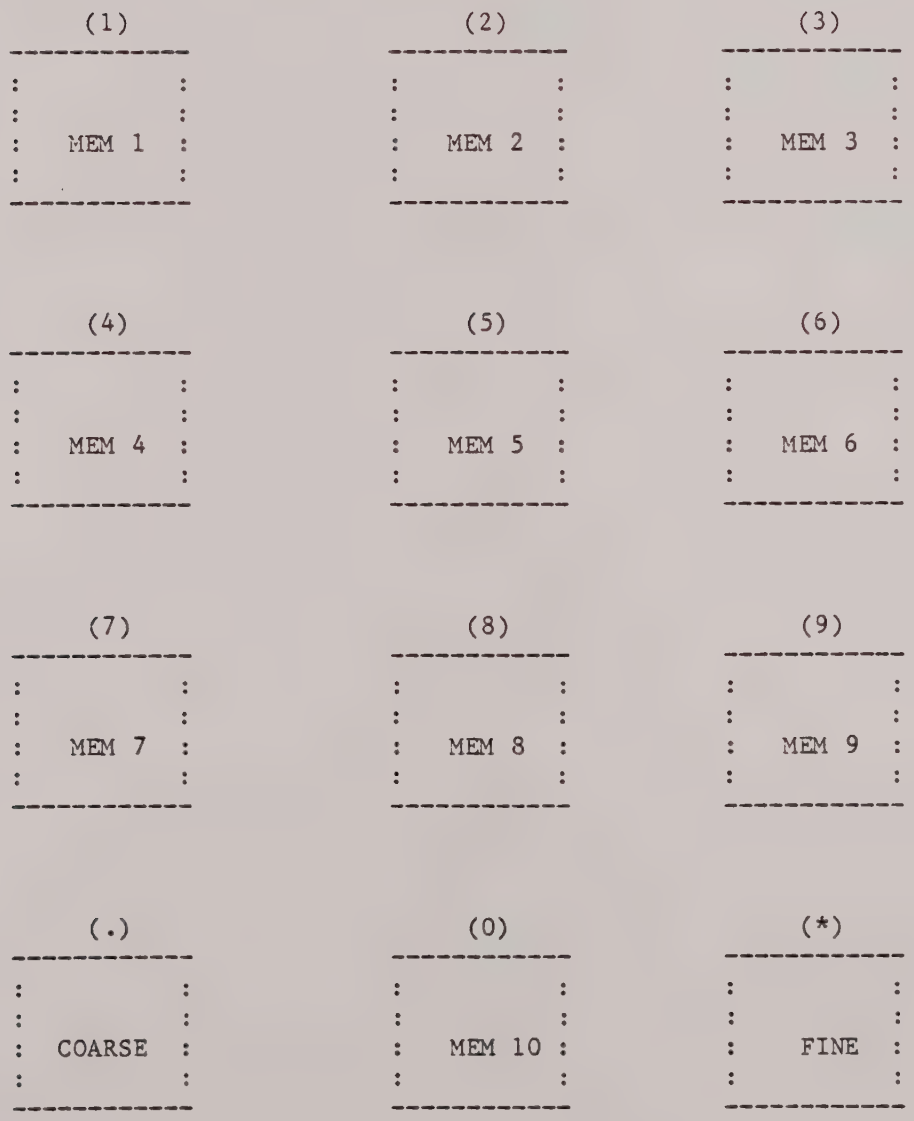
| SWITCH 6 | SWITCH 7 | SWITCH 8 | Data Format Parity | Bits | Stop Bits |
|---|---|---|---|---|---|
| 0 | 0 | 0 | none | 8 | 2 |
| 1 | 0 | 0 | none | 8 | 1 |
| 0 | 1 | 0 | even | 8 | 1 |
| 1 | 1 | 0 | odd | 8 | 1 |
| 0 | 0 | 1 | even | 7 | 2 |
| 1 | 0 | 1 | odd | 7 | 2 |
| 0 | 1 | 1 | even | 7 | 1 |
| 1 | 1 | 1 | odd | 7 | 1 |

## Table 4.3 - Error Codes

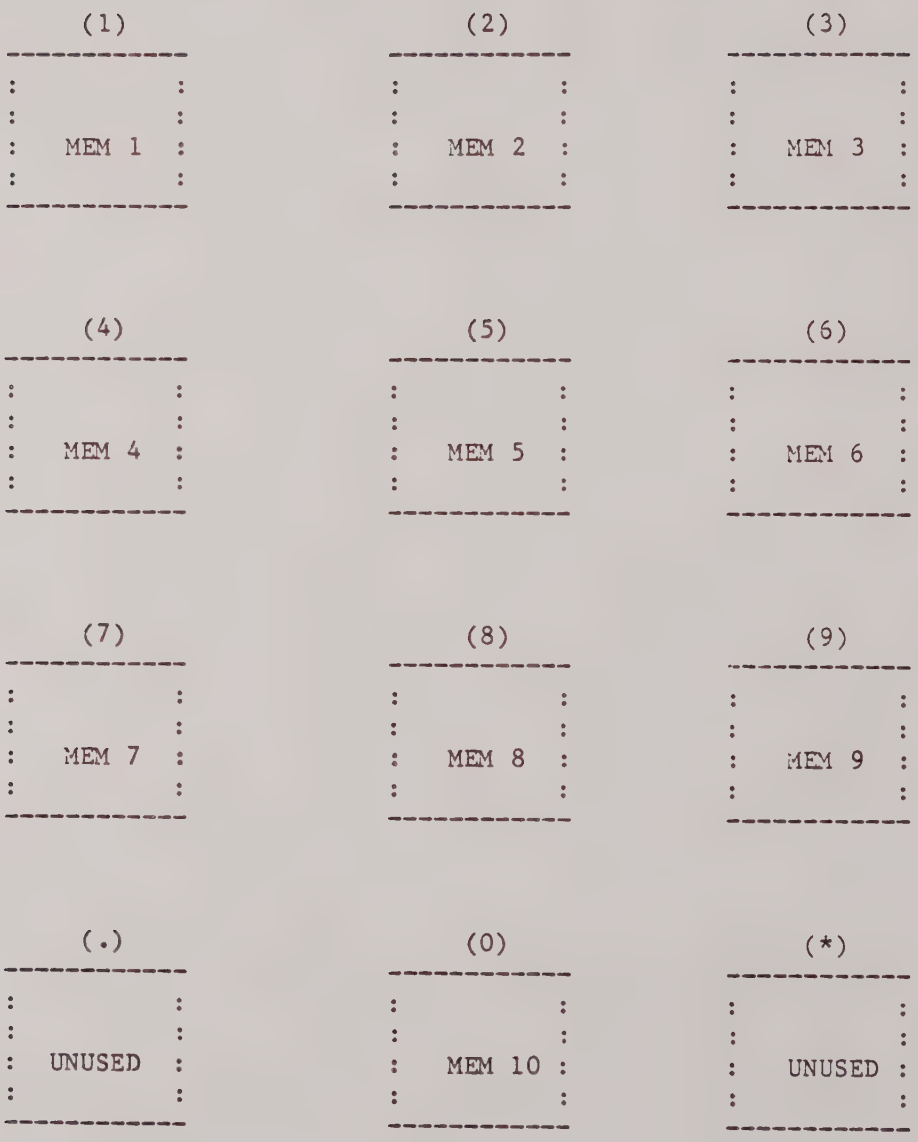
| | CODE | MEANING |
|---|---|---|
| Command Error | E10 | Unrecognized Command |
| | E11 | Missing Parameter |
| | E12 | Illegal or Missing Multiplier |
| | E13 | Unrecognized Units |
| | E14 | Syntax Error in Mantissa |
| | E15 | Syntax Error in Exponent |
| | E16 | -ve Mantissa Illegal |
| | E17 | Value Out-of-Range |
| | E18 | Invalid Baud Rate |
| Input - Output Errors | E30 | Device in Local Mode |
| | E31 | Buffer in Local Mode |
| | E32 | RS-232C Parity Error |
| | E33 | RS-232C Framing Error |
| | E34 | RS-232C Overrun Error |

## 5.1 APPENDIX 1 - LAYOUT OF KEYS FOR PAGES 1-3

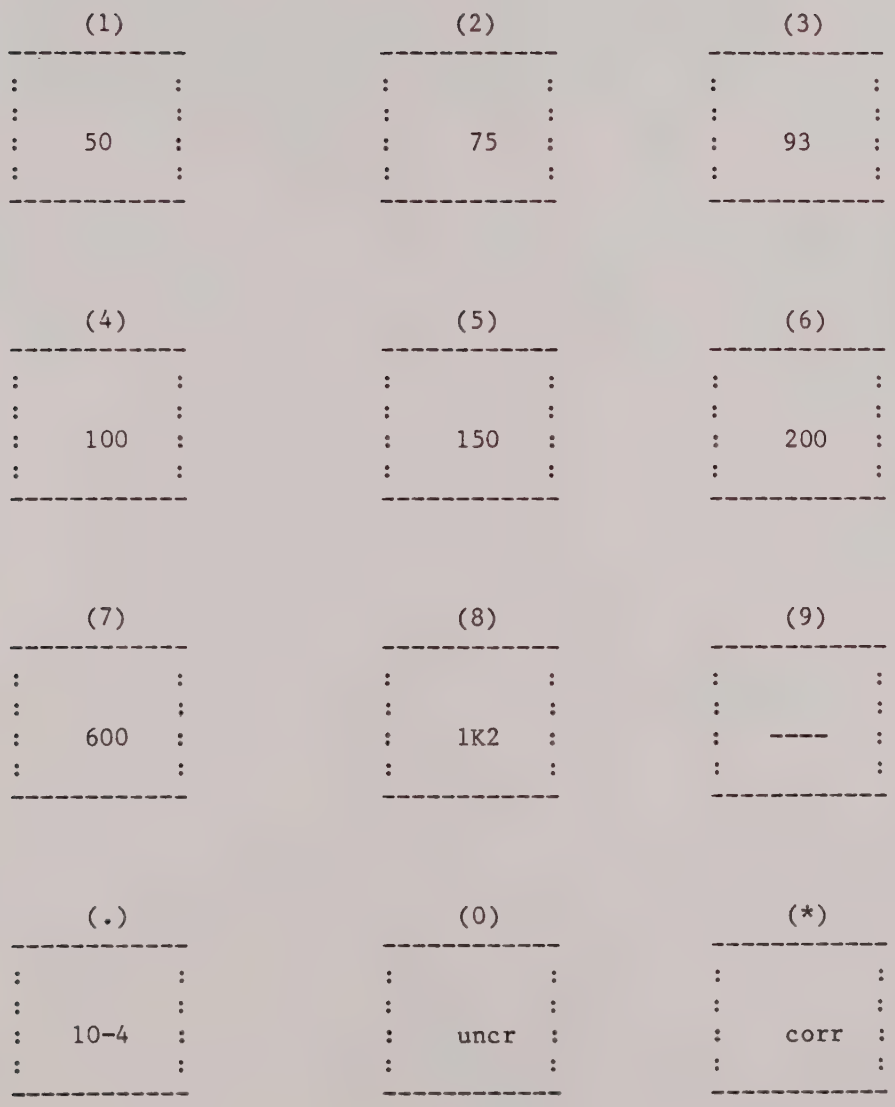
### 5.1.1 PAGE 1 - Store to Memory



### 5.1.2 PAGE 2 - Recall from Memory



### 5.1.3 PAGE 3 - Set Reference Impedance and Load



## 5.2 APPENDIX 2 - IEEE-488 Control from BASIC, Example Programs

5.2.1 The following example is of a BASIC program suitable for interactive control using the VIC20 with an INTERPOD. The user is prompted for a command which is sent to the IEEE interface using an arbitrary file (5), and address (7) as set up on the interface dip switches and an arbitrary secondary address (12). Note that the secondary address is not optional! The program loops around waiting for a reply and if one is received within an arbitrary number (10) of attempts it is printed, otherwise the message "NO REPLY" is output.

```
10  PRINT "(CLR)"
20  INPUT "COMMAND";A$
30  OPEN5,7,12
40  PRINT#5,A$
50  B$="NO REPLY"
60  FOR L=0 TO 10
70  INPUT#5,B$
80  IF B$()"NO REPLY" THEN 100
90  NEXT
100 CLOSE5
110 PRINT
120 GOTO 20
```

The format of the dialogue is as follows:

```
    prompt from program
    !       user response (CR repeats previous input)
    !       !
COMMAND?    X
XXXXXXX
    !
    response from program
```

An interactive dialogue might be e.g. (with added comments):

```
COMMAND? F              - read frequency
F99.0HZ                 - reply
COMMAND? 0.1HZ          - set frequency
E10                     - no command character
COMMAND? F0.1HZ         - set frequency
E17                     - out of range
COMMAND? F10HZ          - set frequency
NO REPLY                - no errors so expect to be OK
COMMAND? F              - read new frequency
F10.0 HZ                - there it is
```

5.2.2 An alternative program, shorter and somewhat more sophisticated, handles multiple replies as follows:

```
20  DIM A$[80],B$[80]
30  INPUT A$
40  IF A$<>"" THEN 70
50  A$=B$
60  DISP A$
70  B$=A$
80  OUTPUT 707 ; A$
90  ENTER 707 ; A$
100 IF A$<>"" THEN DISP A$
110 IF A$="" THEN 10
120 GOTO 90
```

This was developed for integration on an HP85 and uses the fact that the interface will send a null string if the GPIB goes into the TACS state and the LDO is not busy. (This feature was added during integration to prevent the bus being "hung up" by a read when no data was being generated). The user can enter a series of commands (using ";" as separator) and will receive as many replies as are generated.

## 5.3 APPENDIX 3 - Programming Techniques

### 5.3.1 Remote and Local Operation

These commands select one of two modes for controlling the instrument. These are the instruments' own (local) front panel or an external (remote) controller. Remote/Local selection can be made in software. The reason for these commands is to facilitate Remote/Local control from the RS232 port. When using the RS232 interface, the LDO should always be sent the remote command "L" before sending control instructions. The IEEE-488-bus has its own special implementation of Remote/Local that is part of the IEEE-488 specification. The method of invoking them is dependent upon the programming techniques used by the controller. However, because all oscillator commands are accessible from either remote input port, the IEEE-488 controller can make use of the software commands for Remote and Local, and this can be useful with controllers that implement a subset of the IEEE-488 specification excluding remote and local commands.

### 5.3.2 Avoiding apparent Bus "hang-up"

There are certain circumstances where the LDO may appear to "hang-up" a controller. In fact, the controller "holds-up" itself waiting for a reply. For example, when the 'C' command is sent to set the LDO into self-calibrate any request for information during the self-calibration period will "hang-up" the controller. A solution to this problem is to have a timeout on such bus transactions. If a reply is not received within a predetermined time interval, the controller returns without data, enabling program execution to continue. Some controllers have commands in their control language that specifically deal with the setting of timeout periods. Other controllers have a timeout capability always operative.

### 5.3.3 Serial Poll

The LDO does not use the service request (SRQ) message. If the instrument is serially polled, it will respond by putting a status byte on the bus in the normal way. Bit 3 of this byte will be 1 if the LDO is in Remote and zero if in Local.

### 5.3.4 Parallel Poll

The LDO does not make use of Parallel Polling and will ignore any Parallel Polling or configuring commands sent to it.

### 5.3.5 Device Clear

Sending the IEEE-488-bus command DEVICE CLEAR will cause the LDO to perform a "cold" reset. That is, it will clear PAGE 3 conditions to 600 ohms and open the circuit; turn ON the whole display for one second; revert to operation in the lowest frequency and amplitude ranges showing frequency and main amplitude output voltage; and go to LOCAL.

```
   DIM A$[80]
   ASSIGN @Ldo TO 711
   ASSIGN @Hpib TO 7
   ON TIMEOUT 7,6 GOTO Timeout
   !
   !
Loop: INPUT A$
   !
   IF A$="Z" THEN Local
   IF A$="Q" THEN Remote
   IF A$="LL" THEN Local_lockout
   IF A$="UL" THEN Unlock
   IF A$="SP" THEN Serial_poll
   IF A$="DC" THEN Reset
   IF A$="C" THEN Calibrate
   !
   PRINT A$
   OUTPUT @Ldo;A$
   !
Enter: WAIT .2
   ENTER @Ldo;A$
   PRINT A$
   IF A$="" THEN Loop
   GOTO Enter
   !
   !
Local: LOCAL @Ldo
   PRINT "Local"
   GOTO Loop
   !
Remote: REMOTE @Ldo
        PRINT "Remote"
        GOTO Loop
   !
Local_lockout: LOCAL LOCKOUT @Hpib
               PRINT "Local Lockout"
               GOTO Loop
   !
Unlock: LOCAL @Hpib
        WAIT 2
        REMOTE @Ldo
        PRINT "Unlock"
        GOTO Loop
   !
Serial_poll: Spoll_stat=SPOLL(@Ldo)
             PRINT "Serial poll status byte = ";Spoll_stat
             WAIT .5
             GOTO Loop
   !
Timeout: PRINT "Bus timeout"
         GOTO Loop
   !
Reset: CLEAR @Ldo
   WAIT 5
   GOTO Remote
   !
```

```
Calibrate: OUTPUT @Ldo;"L"
           WAIT 1
           OUTPUT @ Ldo;"C"
           WAIT 100
           OUTPUT @Ldo;"L"
           WAIT 1
           GOTO Loop
   !
END
```

### 5.3.6 Program Explanation I

Below is a program for the Hewlett Packard 9816 which demonstrates the use of Remote/Local bus commands, serial polling, device clear and auto-calibrate.

LDO bus address is 11; the 9816 interface address is 7.
Line 4 indicates that if a reply is not received from the bus within 6 seconds, the programme should proceed to the timeout routine. This feature can be used within programs to trap error conditions.

Loop — Input a command from the keyboard, look for command codes, go to the relevant subroutine or immediately output to LDO.

Enter — Wait 0.2 seconds for the transactions to complete and then read a byte of data from the LDO. If data from LDO is a null byte, go back to loop for another keyboard command. If not, print the data received and go back to enter for more.

Local — IEEE 488 bus command LOCAL

Remote — IEEE 488 bus command REMOTE

Local Lockout — IEEE 488 bus command LOCAL LOCKOUT

Unlock — This takes LDO out of Local Lockout, but returns the instrument to remote operation. Local Lockout and Local both operate on the controller. Local should always be followed by the Remote LDO command to avoid the instrument operating in an undefined state.

Serial Poll — Performs a serial poll and prints the status byte received. Value will be 8 or 0 for Remote or Local operation.

Timeout — This subroutine prints the message "Bus timeout" if for any reason the controller does not receive a reply from the oscillator.

Reset — Sends Device Clear to LDO, waits for it to perform a "cold" reset and then puts the instrument into Remote operation.

Calibrate — This sequence must be used to avoid bus programming errors. Enables Remote LDO using the software command, initiates auto-calibrate, waits 100 seconds for completion, returns instrument to Remote again using software command and exits.

### 5.3.7 Program Explanation II

The following program demonstrates the LDO's IEEE-488 control capabities using a Hewlett-Packard 9816. The program is a practical example with much of it describing screen formatting.

Apart from the repertoire of commands defined in Table 4.1, there are two in addition:

S - will display the "status" of the instrument by sending a multiple command string in subroutine STATUS.

Z - starts by loading the LDO's 10 memory locations and then goes into a loop that varies the amplitude, frequency, and recalls the memory locations in turn. Once started, the only way to exit this loop is to BREAK the program.

In this program, multiple commands are handled by counting the number of commands sent using the Count"comms" routine and then inputting that specific number of commands in the routine starting at "Fetch".

Subroutine Com_proc looks for a few, but not all of the possible replies by looking at the first letter and then dealing with each separately. Subroutine Imp demonstrates how to convert the received impedance reference voltage into a value in ohms. If the first letter is an E, then the Err subroutine is entered. This prints the appropriate error message from the array defined in Def-error-array.

The program from Auto-prog down to Loop2 sets the LDO to a defined state and loads the non-volatile memories. Note the technique of using a dummy Enter command to ensure that the LDO is ready to accept the next data message. Failure to do this can result in the LDO interface computer overwriting data in its circular input buffer. This causes loss of commands.

The program between Loop2 and END uses a series of loops to step automatically and continuously through a series of amplitude and frequency changes, and memory locations using both the Main and Auxilliary Outputs.

```
ON TIMEOUT 7,2 GOTO Timeout ! if osc doesn't reply after 2 secs - quit
GOSUB Def_error_array
GOSUB Clear_screen
GOSUB Line
ASSIGN @Oscl TO 711
DIM A$[30]
PRINTER IS 1
REMOTE @Oscl
Loop: INPUT Data$
IF Data$[1,1]="Z" THEN GOTO Auto_prog
IF Data$[1,1]="S" THEN GOSUB Status ! this is a request to display all
!
IF Data$="U" THEN GOSUB Local
IF Data$()"U" THEN GOSUB Remote
!
GOSUB Count_comms ! find how many separate commands we have
OUTPUT @Oscl;Data$
Fetch: WAIT .1
       ENTER @Oscl;A$
       GOSUB Line
       GOSUB Show_raw_data
       GOSUB Com_proc
       IF Num_coms=1 THEN Exit
       Num_coms=Num_coms-1
       GOTO Fetch
Exit: GOTO Loop
!
Com_proc:!
         X$=A$[1,1]
         IF X$="A" THEN Ampl
         IF X$="F" THEN Freq
         IF X$="I" THEN Imp
         IF X$="T" THEN Auxt
         IF X$="V" THEN Auxv
         IF X$="D" THEN Auxd
         IF X$="E" THEN Err
         RETURN
Ampl:!
     PRINT TABXY(29,4),"Amplitude.. ";A$[2,LEN(A$)];"          "
     RETURN
Freq:!
     PRINT TABXY(29,6),"Frequency.. ";A$[2,LEN(A$)];"          "
     RETURN
Imp:!
     O=1000*((VAL(A$[2,6]))^2)
     PRINT TABXY(19,8),"Reference impedance.. ";O;" ohms";"     "
     RETURN
Auxt:! Process auxiliary repliess
     GOSUB Print_aux
     PRINT TABXY(42,10),"TTL                "
     RETURN
```

```
Auxv:! Process auxiliary replies
     GOSUB Print_aux
     PRINT TABXY(42,10),"Variable pulse ..";A$[2;3];" volts        "
     RETURN
Auxd_! Process auxiliary replies
     GOSUB Print_aux
     PRINT TABXY(42,10),"Variable DC ..";A$[2;3];" volts           "
     RETURN
     !
     !
Print_aux: PRINT TABXY(21,10),"Auxiliary Output.. "
           RETURN
Err: ! show error message
     PRINT TABXY(15,15)," Error condition ......";Error$(VAL(A$[3;1])+1);"
-----------"
     RETURN
Status:!
     !  PRINT "Request for LDO status"
     !  PRINT
        Data$="A;F;I;D"
        RETURN
Clear_screen: !
          FOR Line=1 TO 40
          PRINT
          NEXT Line
          RETURN
Count_comms:! count the number of commands in the input line
          Num_coms=1 ! there is always 1 command
          FOR N=1 TO LEN(Data$)
          IF Data$[N;1]=";" THEN Num_coms=Num_coms+1
          NEXT N
          RETURN
Remote:  PRINT TABXY(1,1),"----- REMOTE OPERATION ---"
         RETURN
Local:   PRINT TABXY(1,1),"------ LOCAL OPERATION -------"
         RETURN
Show_raw_data: !
               PRINT TABXY(10,17),"   data to bus ... ";Data$;"  data from
bus ... ";A$;"          "
         RETURN
Line: ! draw a line above raw data
         PRINT TABXY(1,15),"-----------------------------------------------
--------------------------"
         RETURN
Def_error_array: ! Load error message array
          DIM Error$(9) 33
          Error$(1)="Unrecognized command"
          Error$(2)="Missing parameter"
          Error$(3)="Illegal or missing multiplier"
          Error$(4)="Unrecognized units"
          Error$(5)="Syntax error in mantissa"
          Error$(6)="Syntax error in exponent"
          Error$(7)="-ve mantissa illegal"
          Error$(8)="Value out of range"
          Error$(9)="Invalid baud rate"
          RETURN
```

```
Timeout: PRINT TABXY(60,1),"**** BUS TIMEOUT ****"
     WAIT 2.5
     PRINT TABXY(60,1),"                "
     GOTO Loop
Auto_prog:!
     OUTPUT @Osc1;"L" ! ENSURE LDO is REMOTE
     WAIT .1
     OUTPUT @Osc1;"I.7746VREF;0" ! Set page 3 conditions
     WAIT .1
     OUTPUT @Osc1;"A3V;F20KHZ" ! Set MAIN output level and frequency
     WAIT .1
     OUTPUT @Osc1;"D1V;M1" ! load memory 1
     ENTER @Osc1;A$
     OUTPUT @Osc1;"D2V;M2"
     ENTER @Osc1;A$
     OUTPUT @Osc1;"D3V;M3"
     ENTER @Osc1;A$
     OUTPUT @Osc1;"D4V;M4"
     ENTER @Osc1;A$
     OUTPUT @Osc1;"D5V;M5"
     ENTER @Osc1;A$
     OUTPUT @Osc1;"D6V;M6"
     ENTER @Osc1;A$
     OUTPUT @Osc1;"D7V;M7"
     ENTER @Osc1;A$
     OUTPUT @Osc1;"D8V;M8"
     ENTER @Osc1;A$
     OUTPUT @Osc1;"D9V;M9"
     ENTER @Osc1;A$
     OUTPUT @Osc1;"10V;M10"
     ENTER @Osc1;A$
Loop2:    OUTPUT @Osc1;"A2V;T"
          WAIT 1
          N=1000
          ! Step frequency from 1KHZ to 100 KHZ
          WHILE N<100000
          N=N*1.3
          A$="F"&VAL$(INT(N))&"HZ"
          OUTPUT @Osc1;A$
          GOSUB Com_proc
          WAIT .5
          END WHILE
          !
          OUTPUT @Osc1;"F20KHZ"
          ! step main output from 100mV to 2V
          FOR N=100 TO 2000 STEP 100
          A$="A"&VAL$(INT(N))&"MV"
          OUTPUT @Osc1;A$
          GOSUB Com_proc
          WAIT .5
          NEXT N
          ! output each of the memory locations
          FOR N=1 TO 10
          A$="R"&VAL$(INT(N))
          OUTPUT @Osc1;A$
          GOSUB Com_proc
          WAIT .5
          NEXT N
          !
          GOTO Loop2
END
```

### 5.3.8 Programming Cautions

Commands setting the Main Output level relate to the EMF or open-circuit output voltage. Requests for the Main Output level will return the terminal voltage.

If remote programming proceeds with PAGE 0 operative, (i.e., display of amplitude and voltage), changing the reference impedance will put the voltage display into dBm units.

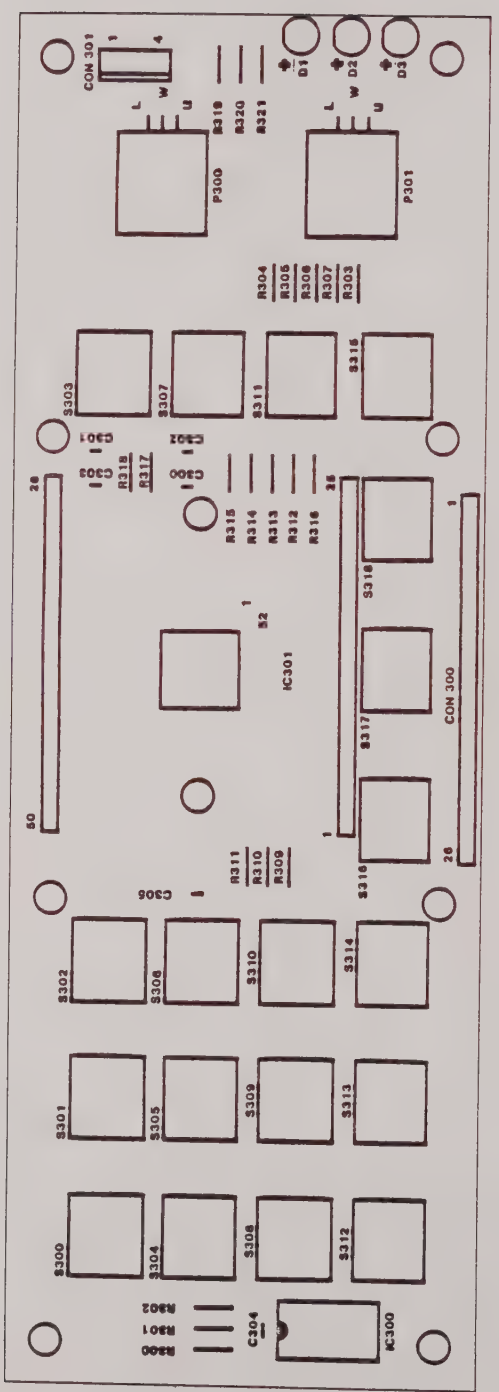
Replies from the LDO giving numerical data have sufficient number of digits for compatibility with the specified instrument accuracy, but no more.

When the LOCAL key is pressed, there is a delay for data to be exchanged via the internal serial interface. Pressing the LOCAL key a second time during this period may cause the front panel "Err" message to be displayed.

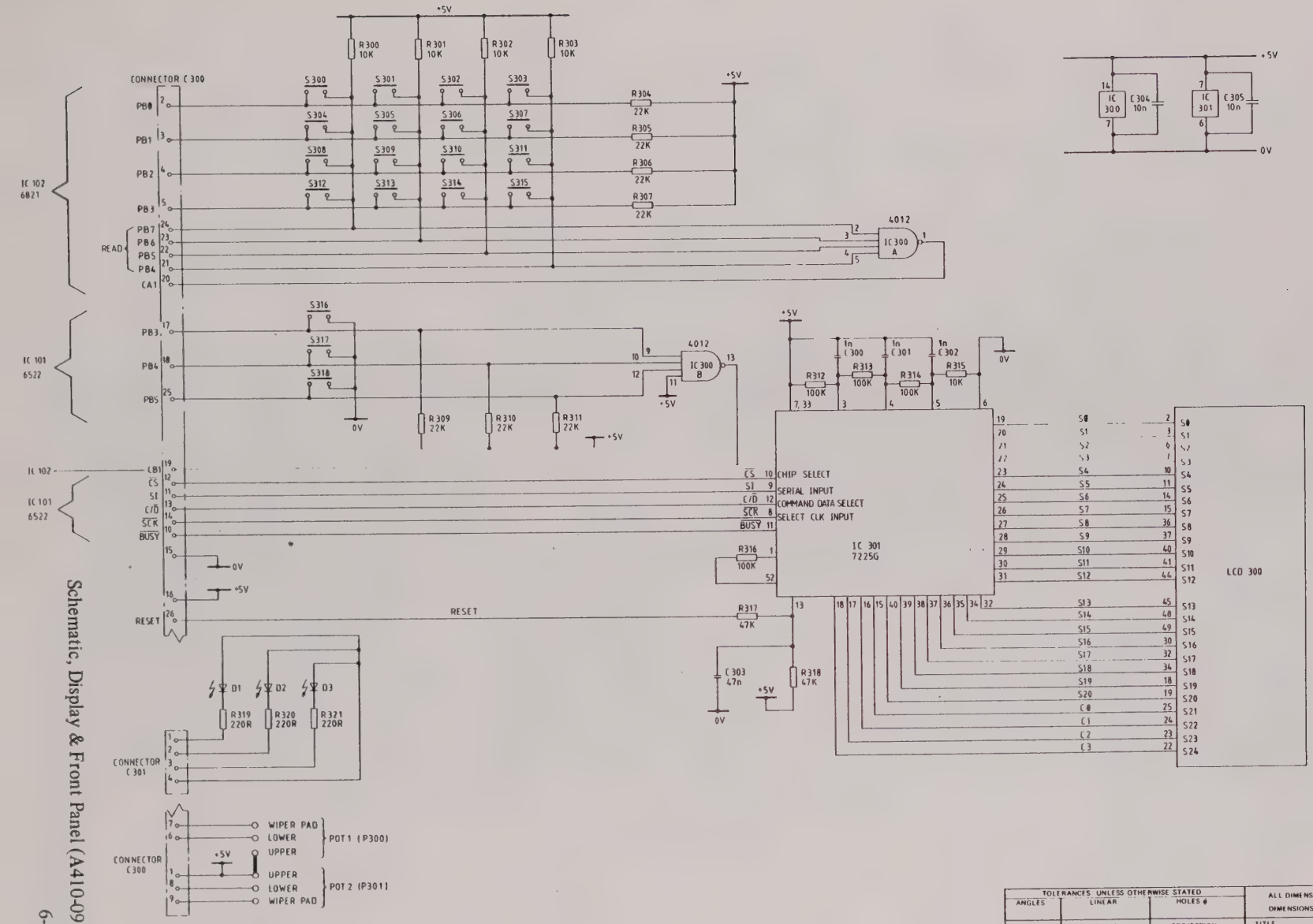
Under conditions of LOCAL LOCKOUT, the LDO front panel will be inoperative, but if the LOCAL key is pressed while data is being received from the interface, the "Err" message may be displayed and some data lost.

# SECTION 6 DRAWINGS


| Titles | Page |
|---|---|
| PCB Layout, Display (A410-042) | 6-2 |
| Schematic, Display & Front Panel (A410-091) | 6-3 |
| PCB Layout, Analog (A410-047) | 6-4 |
| Schematic, Analog (A410-088) | 6-5 |
| PCB Layout, Digital & PSU (A410-037) | 6-8 |
| Schematic, Digital & PSU (A410-087) | 6-9 |
| PCB Layout, IEEE-488 (A410-006) | 6-12 |
| Schematic, IEEE-488 (A410-089) | 6-13 |




PCB Layout, Display (A410-042)




Schematic, Display & Front Panel (A410-091)

6-3

| | | | |
|---|---|---|---|
| 1 | 29 5 84 | | |
| 2 | | | |
| 3 | 3-5-85 | | |

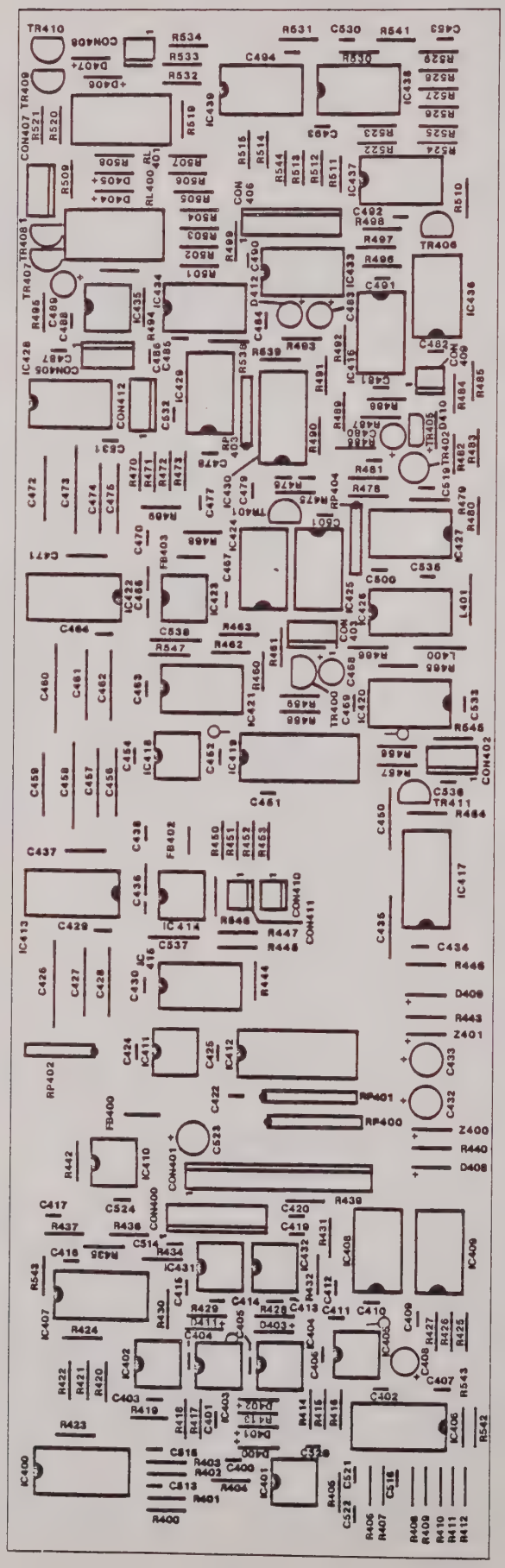
TOLERANCES UNLESS OTHERWISE STATED

| ANGLES | LINEAR | HOLES ⌀ |
|---|---|---|
| APPROVED | SCALE | PROJECTION |
| CHECKED | FINISH | |
| DRAWN | MATERIAL | |

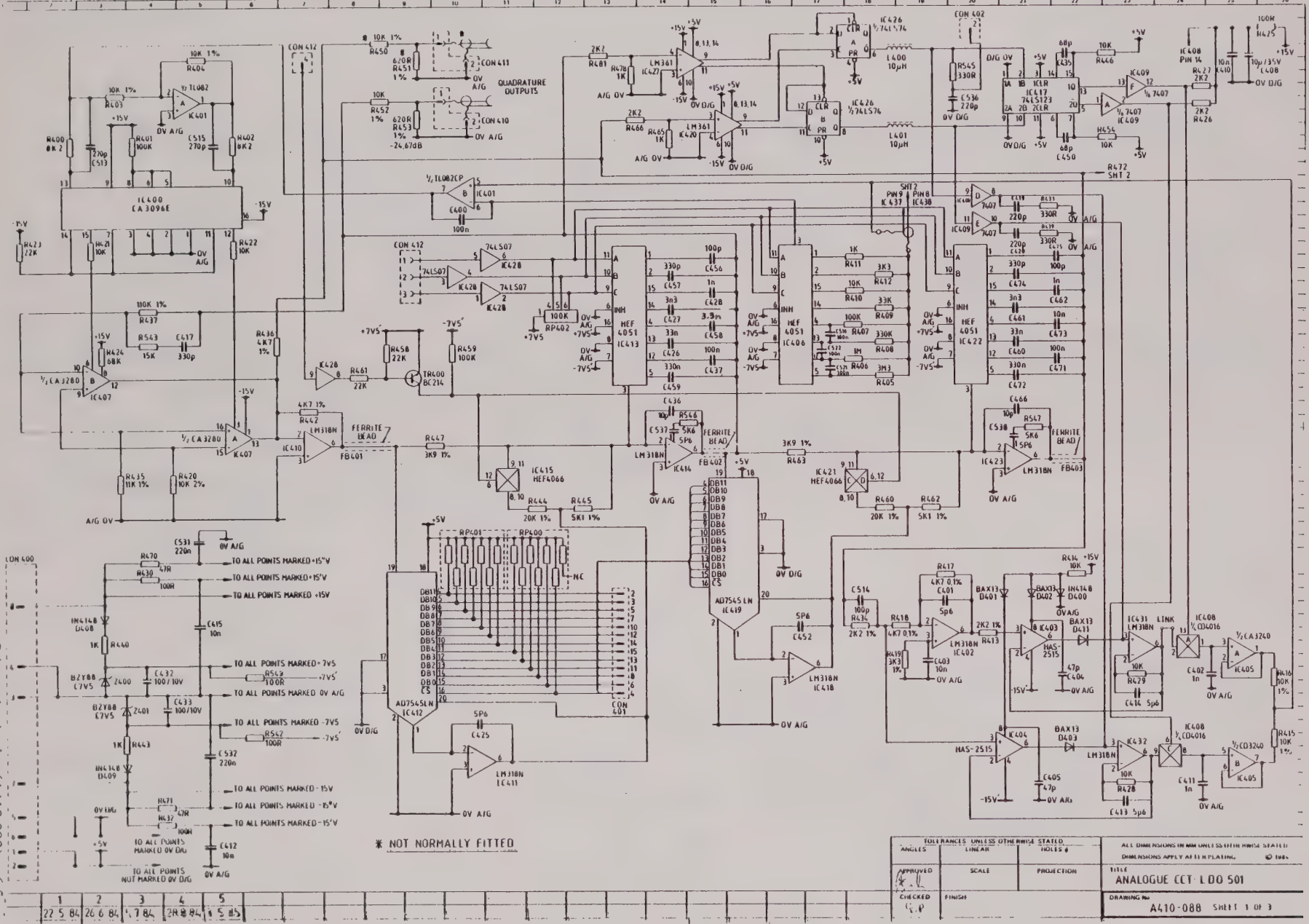
ALL DIMENSIONS IN MM UNLESS OTHERWISE STATED
DIMENSIONS APPLY AFTER PLATING © 1984

TITLE
FRONT PANEL CCT· LDO 501

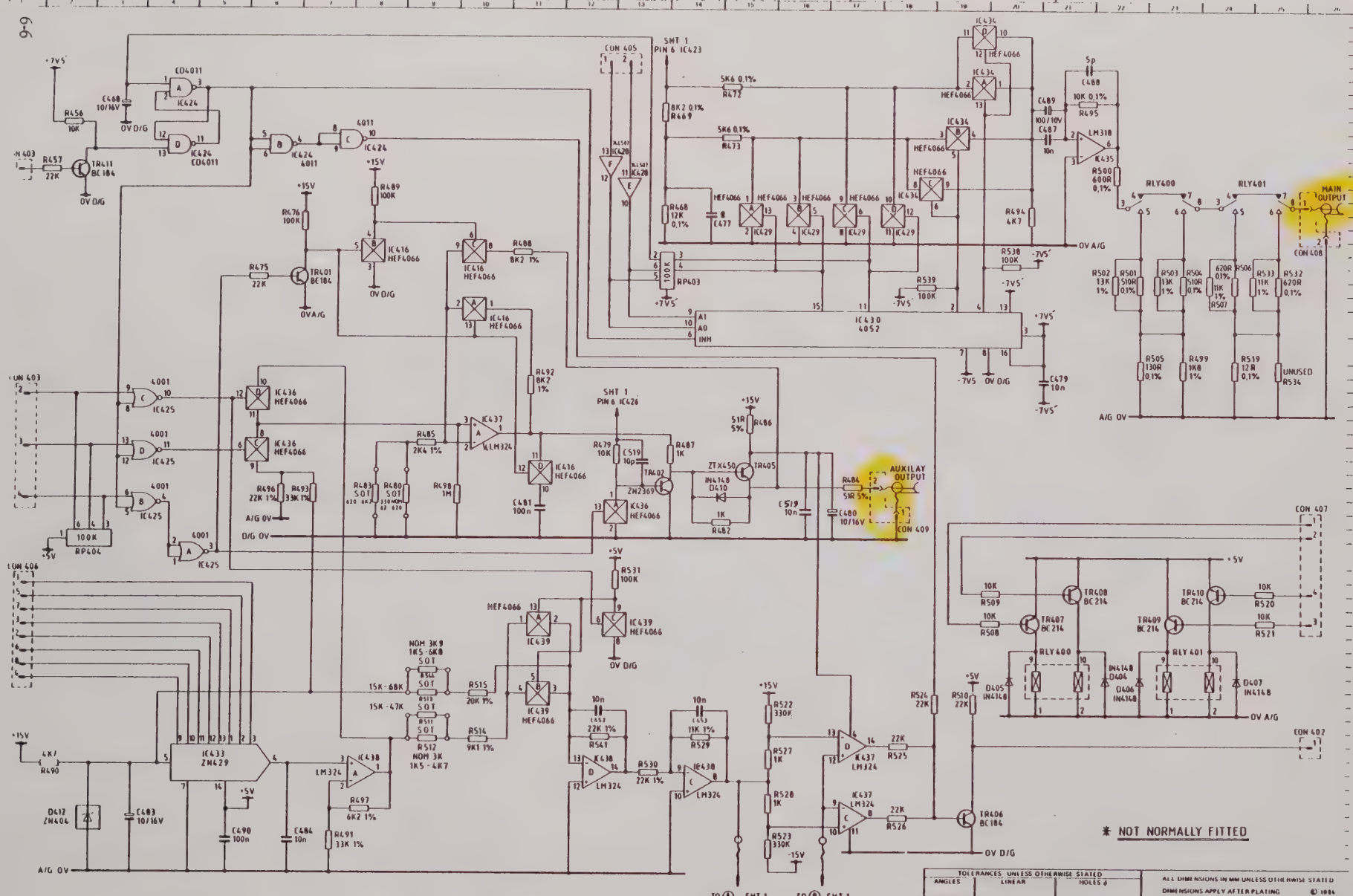
DRAWING No
A410 - 091

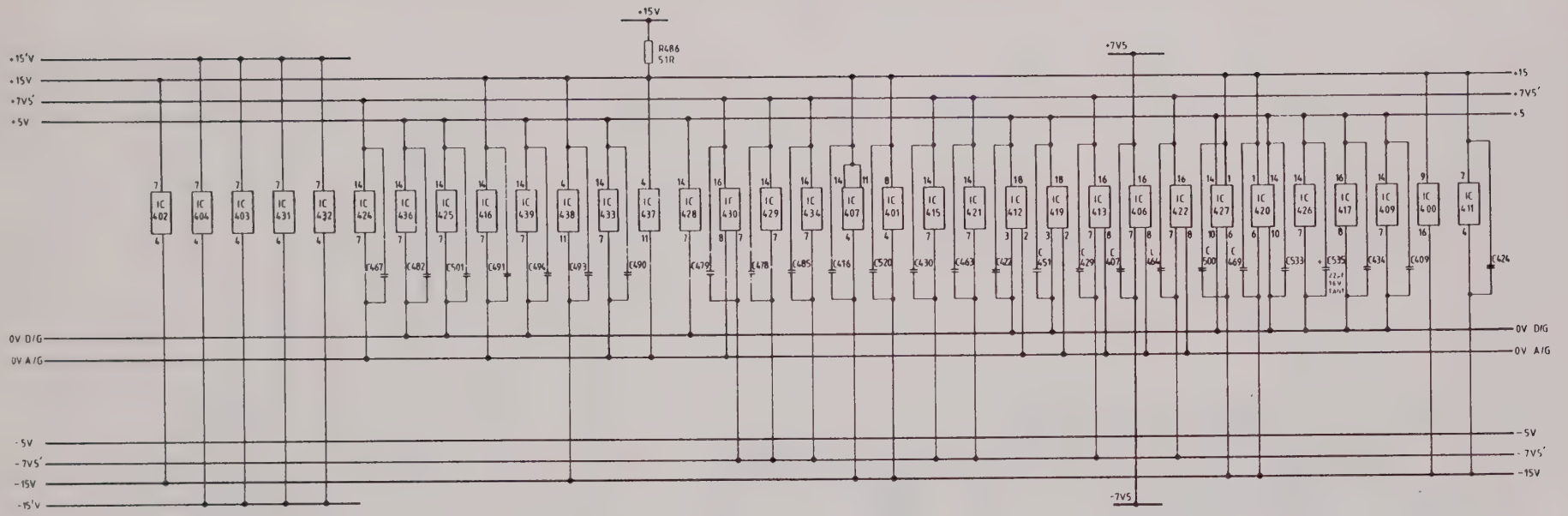


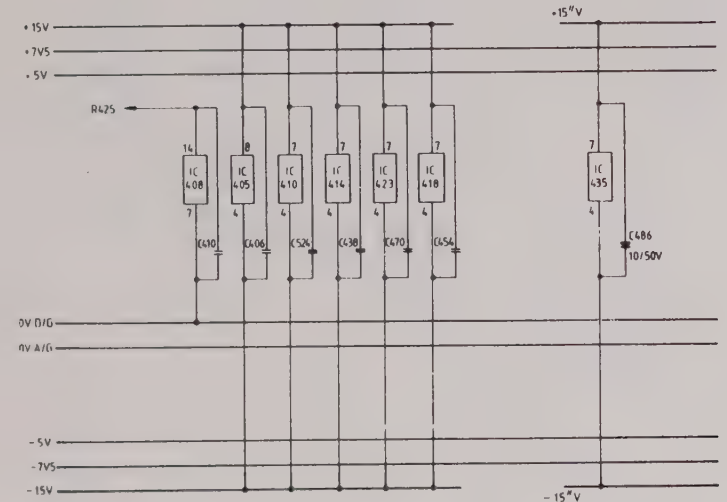
PCB Layout, Analog (A410-047)
6-4




Schematic, Analog (A410-088) 6-5


MAIN OUTPUT
AUXILAY OUTPUT
* NOT NORMALLY FITTED
ANALOGUE CCT · LDO 501
A410-088 SHEET 2 OF 3
TOLERANCES UNLESS OTHERWISE STATED
ALL DIMENSIONS IN MM UNLESS OTHERWISE STATED
DIMENSIONS APPLY AFTER PLATING
TO (A) SHT 1
TO (B) SHT 1




NOTE CAPACITORS 10n UNLESS OTHERWISE SPECIFIED

| | | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| | 6 7 84 | | 3.5.85 |

67

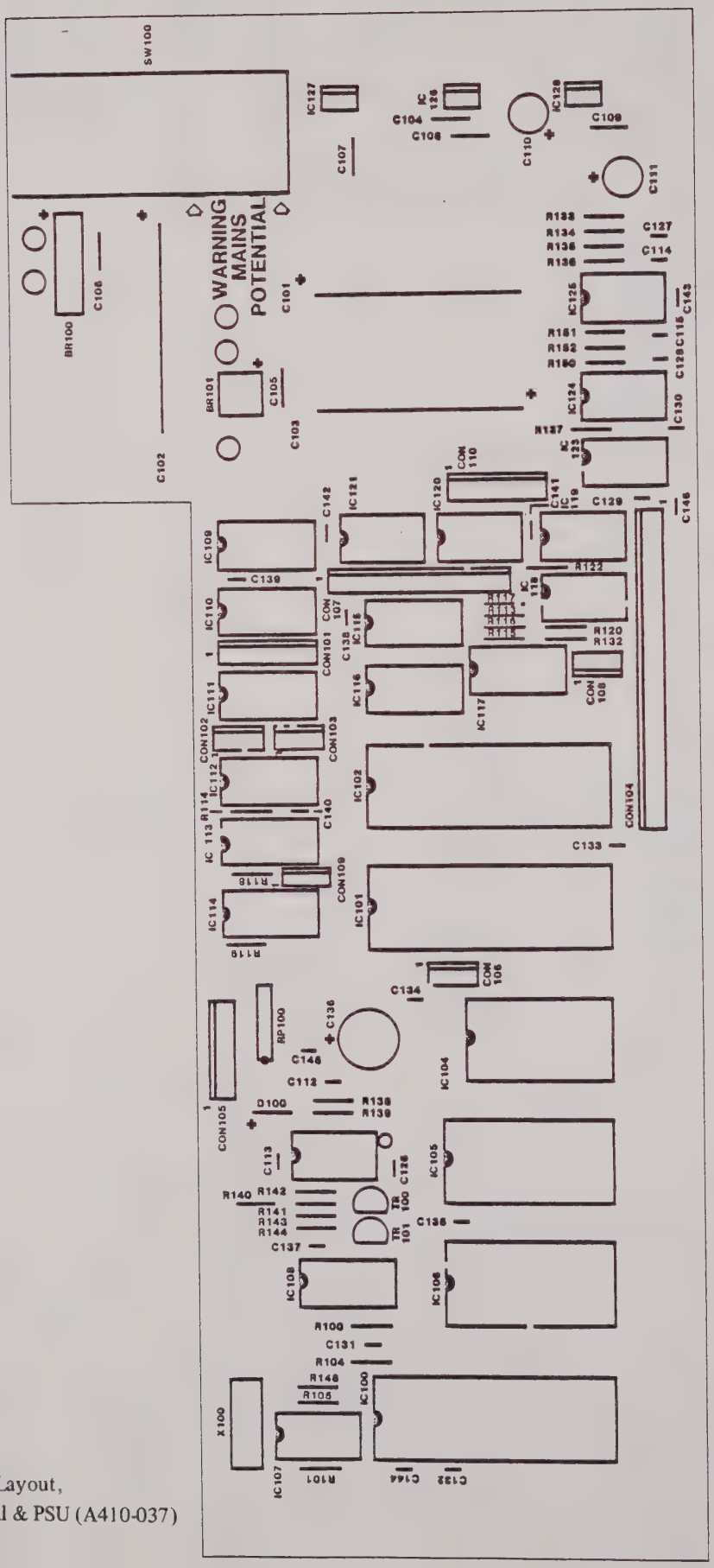
TOLERANCES UNLESS OTHERWISE STATED

| ANGLES | LINEAR | HOLES ⌀ |
|---|---|---|
| APPROVED | SCALE | PROJECTION |
| CHECKED GSP | FINISH | |
| DRAWN | MATERIAL | |

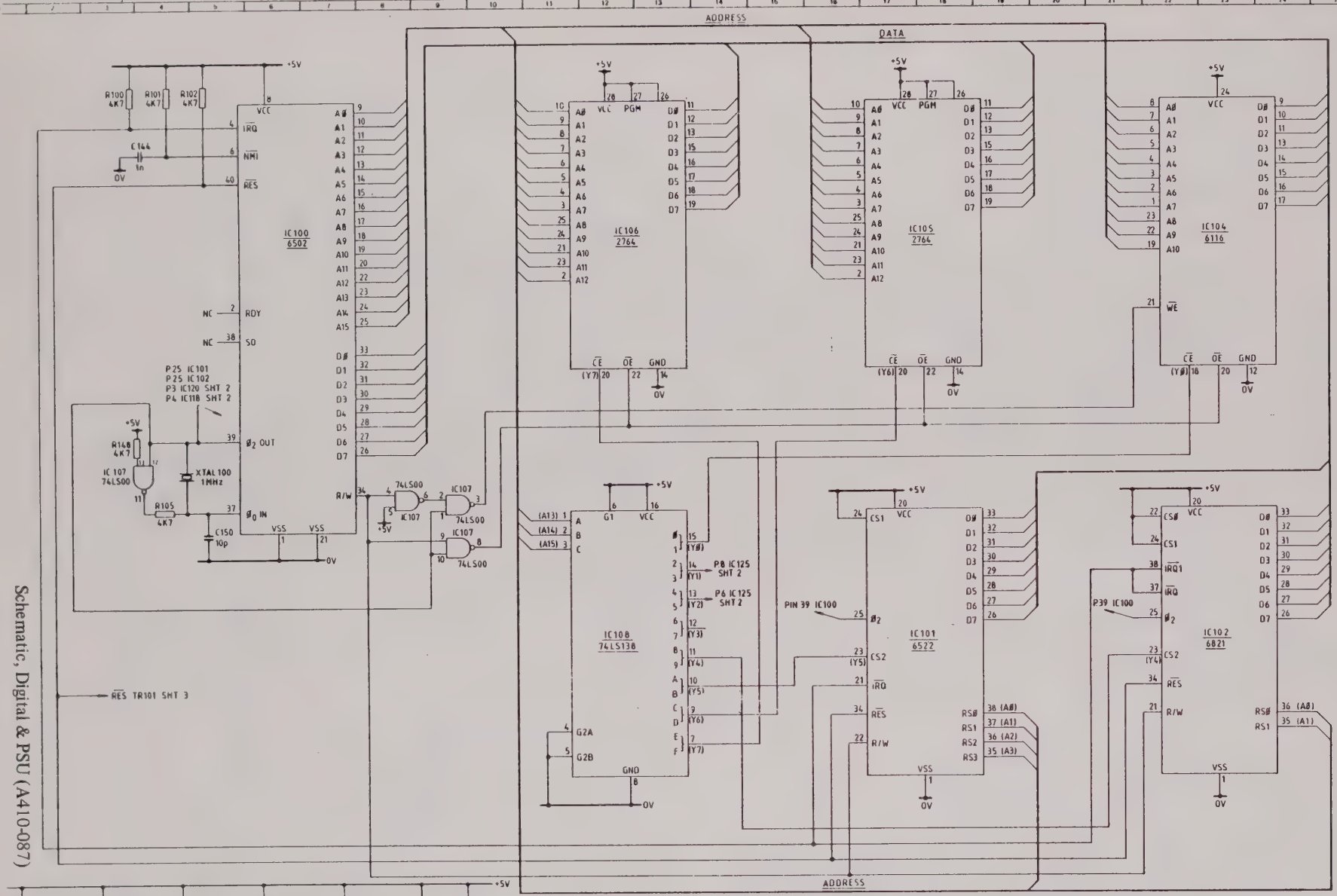
ALL DIMENSIONS IN MM UNLESS OTHERWISE STATED
DIMENSIONS APPLY AFTER PLATING © 198-

TITLE ANALOGUE CCT LDO 501 DECOUPLING CAPACITORS

DRAWING No. A410-088 SHEET 3 OF 3

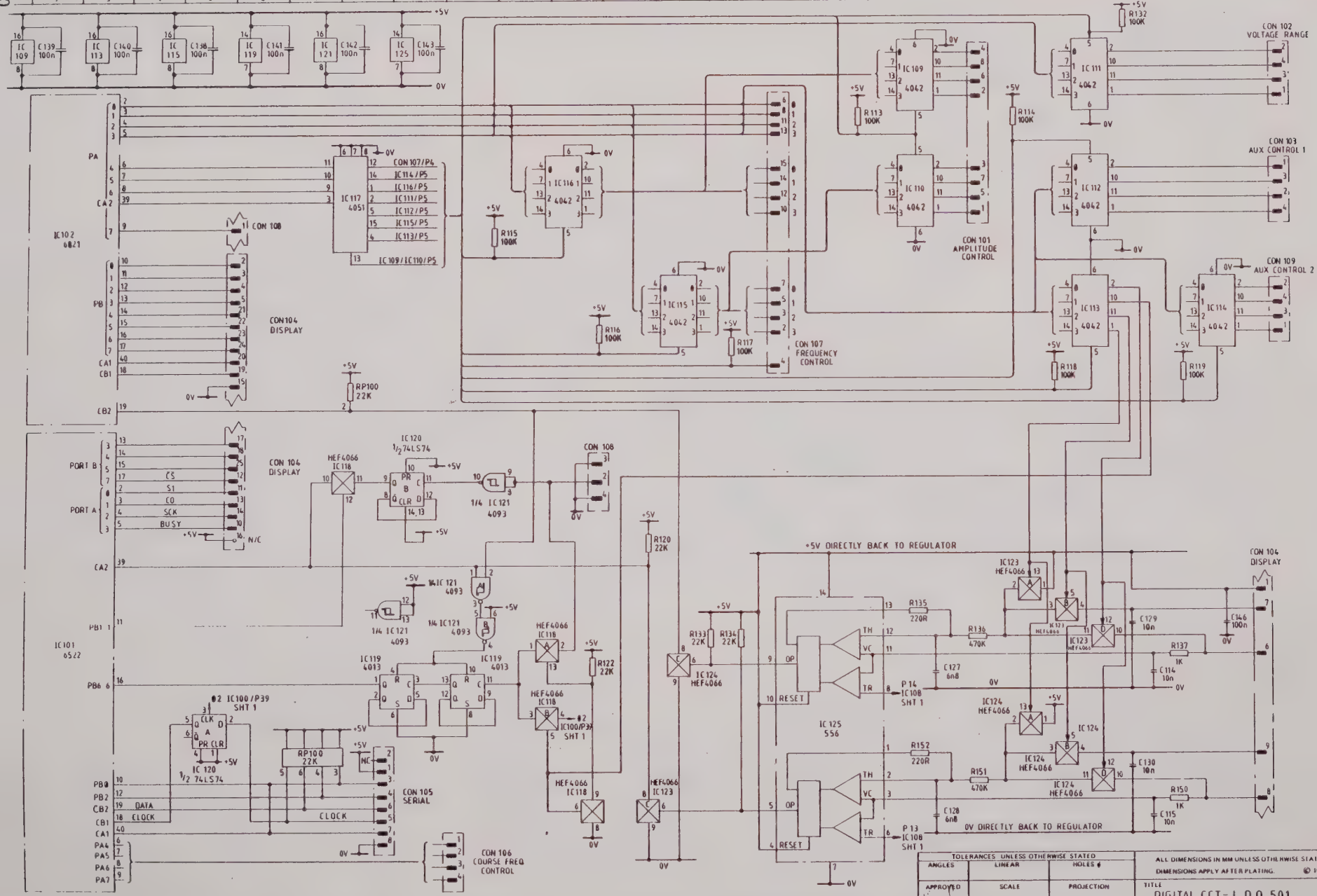



PCB Layout,
Digital & PSU (A410-037)



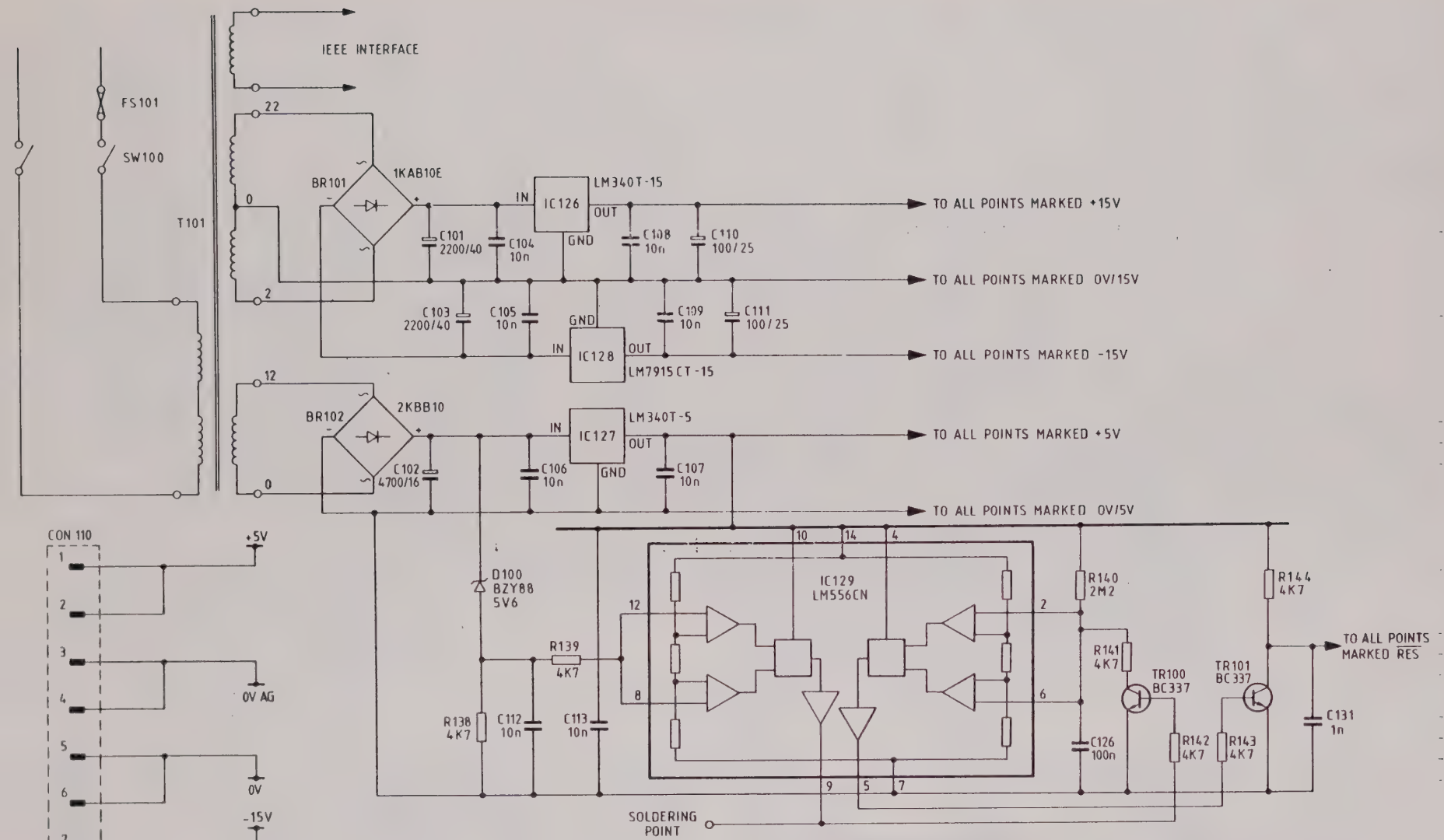

Schematic, Digital & PSU (A410-087)

| | | |
|---|---|---|
| TOLERANCES UNLESS OTHERWISE STATED | | ALL DIMENSIONS IN MM UNLESS OTHERWISE STATED |
| ANGLES | LINEAR / HOLES ⌀ | DIMENSIONS APPLY AFTER PLATING © 19 |
| APPROVED | SCALE / PROJECTION | TITLE: DIGITAL CCT · LDO 501 |
| CHECKED | FINISH | DRAWING No. A410-087 SHEET 1 OF 3 |
| DRAWN | MATERIAL | |




| TOLERANCES UNLESS OTHERWISE STATED | | | ALL DIMENSIONS IN MM UNLESS OTHERWISE STATED |
|---|---|---|---|
| ANGLES | LINEAR | HOLES ⌀ | DIMENSIONS APPLY AFTER PLATING. © |
| APPROVED | SCALE | PROJECTION | TITLE: DIGITAL CCT - L D O 501 |
| CHECKED GSP | FINISH | | DRAWING No: A410-087 SHEET 2 OF 3 |
| DRAWN | MATERIAL | | |

| 1 | 2 | 3 | 4 |
|---|---|---|---|
| 25584 | 20684 | — | 3585 |




| TOLERANCES: UNLESS OTHERWISE STATED | | |
|---|---|---|
| ANGLES | LINEAR | HOLES ⌀ |
| APPROVED | SCALE | PROJECTION |
| CHECKED | FINISH | |
| DRAWN | MATERIAL | |

ALL DIMENSIONS IN MM UNLESS OTHERWISE STATED.
DIMENSIONS APPLY AFTER PLATING. © 1984

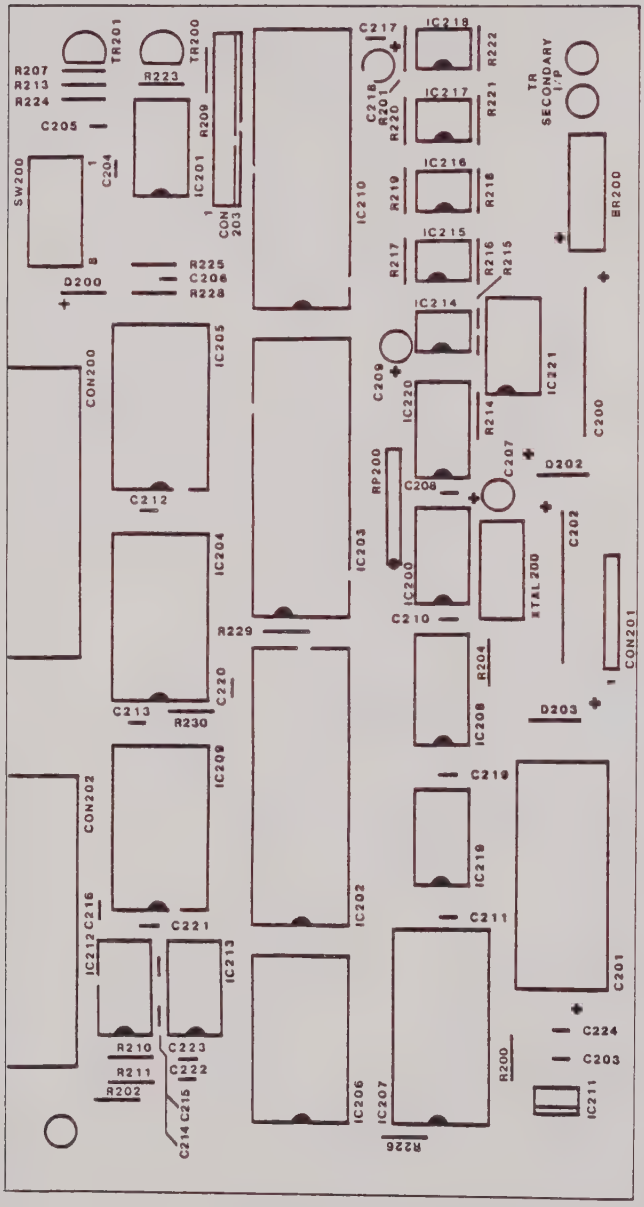
TITLE
PSU CCT-LDO 501

DRAWING No.
A410-087 SHEET 3 OF 3

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| E | 24 5 84 | 11 7 84 | — | 3-5-85 |
| E | | | | |
| NGE NOTE | | | | |
| TIFIED | | | | |

6-11

4596/7 82


R207
R213
R224
C205
SW200
D200
TR201
TR200
R223
R209
IC201
CON 203
C204
R225
C206
R228
IC210
C217
IC218
R222
C218
R201
R220
IC217
R221
TR SECONDARY I/P
IC216
R219
R218
ER200
IC215
R217
R216
R215
IC214
C209
IC220
IC221
R214
C200
CON200
IC205
C212
RP200
C208
C207
D202
IC204
IC200
C210
XTAL200
C202
IC203
R229
C220
C213
R230
R204
IC208
CON201
D203
C219
CON202
IC209
IC219
C211
C221
IC212
C216
IC213
C201
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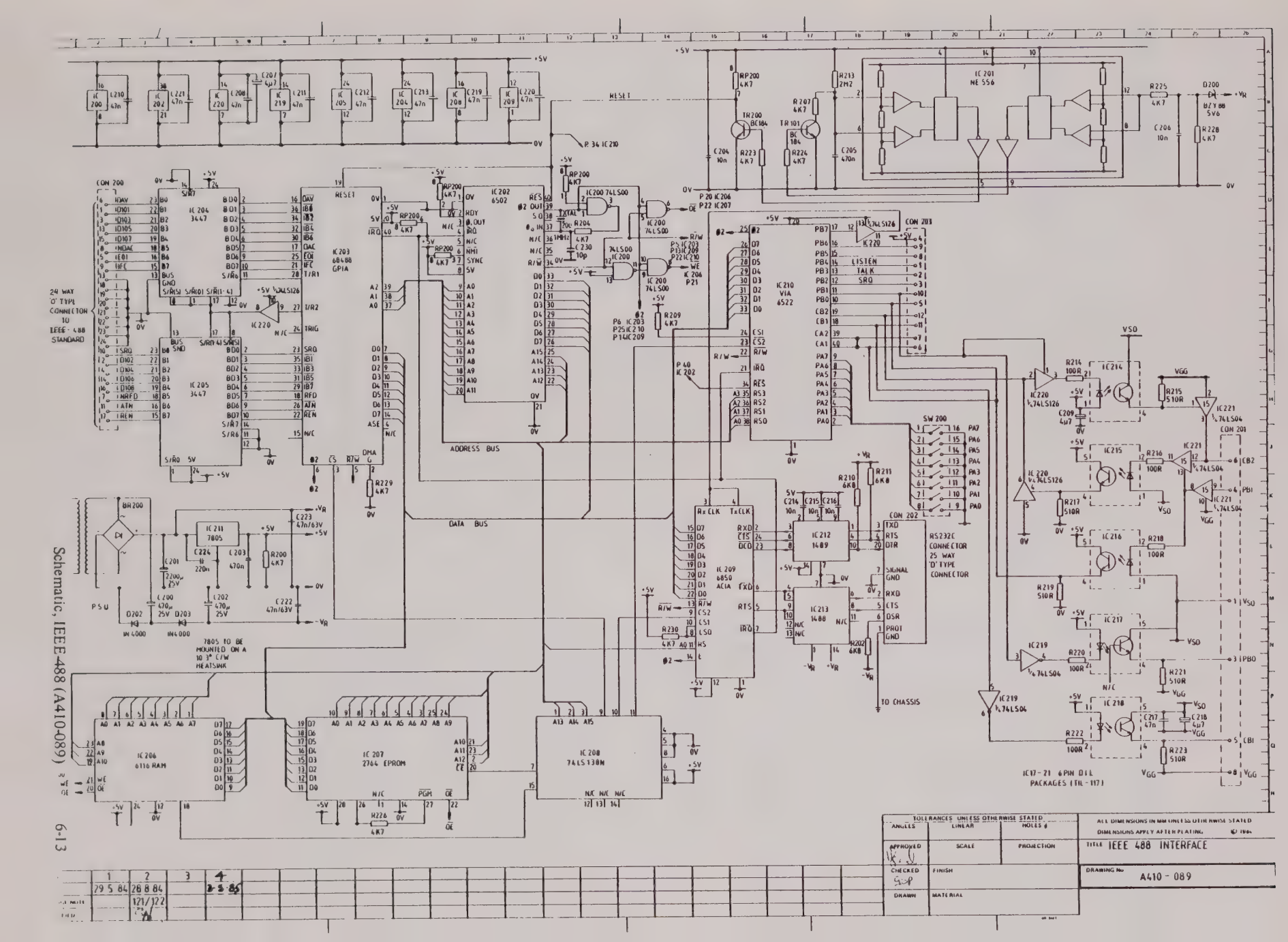
R202
C214
C215
R200
IC206
IC207
IC211
R226


IEEE 488 INTERFACE
A410 - 089
Schematic, IEEE 488 (A410-089)
6-13
24 WAY 'D' TYPE CONNECTION TO IEEE - 488 STANDARD
CON 200
IC 204 3447
IC 205 3447
IC 202 6502
IC 203 6888 GPIA
IC 209 6850 ACIA
IC 210 VIA 6522
IC 212 1489
IC 213 1488
IC 201 NE 556
IC 206 6116 RAM
IC 207 2764 EPROM
IC 208 74LS138N
IC 211 7805
RS232C CONNECTOR 25 WAY 'D' TYPE CONNECTOR
CON 202
CON 203
CON 201
SW 200
ADDRESS BUS
DATA BUS
RESET
PSU
7805 TO BE MOUNTED ON A 10 °C/W HEATSINK
IC17 - 21 6 PIN DIL PACKAGES (TIL - 117)
TO CHASSIS
TOLERANCES UNLESS OTHERWISE STATED
ANGLES
LINEAR
HOLES ϕ
ALL DIMENSIONS IN MM UNLESS OTHERWISE STATED
DIMENSIONS APPLY AFTER PLATING
APPROVED
SCALE
PROJECTION
TITLE IEEE 488 INTERFACE
CHECKED
FINISH
DRAWING No A410 - 089
DRAWN
MATERIAL
29 5 84
28 8 84
23 5 85

# SECTION 7 PARTS LIST

7.1 This section contains lists of replaceable parts arranged in the order of the following subassemblies:

A410-099 Chassis ..... 7-2
A410-097 Display PCB ..... 7-3
A410-100 Analog PCB ..... 7-6
A410-098 Digital PCB ..... 7-20
A410-007 IEEE-488 PCB ..... 7-25

7.2 Manufacturers are identified by FSC numbers listed in Table 7.1 "List of Suppliers". The code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1,H4-2, and their supplements.

**Table 7.1 - List of Suppliers**

| FSC | NAME |
|---|---|
| 01295 | TEXAS INSTRUMENTS, INC.<br>DALLAS, TX |
| 02660 | AMPHENOL CORP.<br>BROADVIEW, IL |
| 02735 | RCA<br>(SOLID STATE DIVISION)<br>SOMERVILLE, NJ |
| 04713 | MOTOROLA<br>(SEMI-CONDUCTOR PRODUCTS DIV.)<br>PHOENIX, AZ |
| 09023 | CORNELL-DUBILIER ELECTRONICS<br>SANFORD, NC |

**Table 7.1 - List of Suppliers**

| FSC | NAME |
|---|---|
| 18324 | SIGNETICS CORP.<br>SUNNYVALE, CA |
| 21793 | RACAL-DANA INSTRUMENTS INC.<br>IRVINE, CA |
| 22119 | FERRANTI ELECTRIC<br>PLAINVIEW, NY |
| 24355 | ANALOG DEVICES<br>NORWOOD, MA |
| 27014 | NATIONAL SEMI-CONDUCTOR CORP.<br>SANTA CLARA, CA |
| 27264 | MOLEX PRODUCTS CO.<br>DOWNERS GROVE, IL |
| 32997 | BOURNS<br>(TRIMPOT PRODUCTS DIV.)<br>RIVERSIDE, CA |
| 34371 | HARRIS SEMICONDUCTOR<br>MELBOURNE, FL |
| 52531 | HITACHI MAGNETICS CORP.<br>EDMORE, MI |
| 61892 | NEC ELECTRONICS<br>NATICK, MA |
| 71468 | ITT CANNON ELECTRIC<br>SANTA ANA, CA |
| 81349 | MILITARY SPECIFICATION |

A410-099, CHASSIS

| REF DESIG. | RACAL-DANA P/N | DESCRIPTION | FSC | MANU P/N |
|---|---|---|---|---|
| F1 | 105091100 | FUSE, 250 MA, QUICK BLO | 21793 | 105091100 |
| T101 | 105051100 | TRANSFORMER | 21793 | 105051100 |

**A410-097, DISPLAY PCB**

| REF DESIG. | RACAL-DANA P/N | DESCRIPTION | FSC | MANU P/N |
|---|---|---|---|---|
| C300 | 102081102 | CAP, 1 NF, 63V | 09023 | MMP SERIES |
| C301 | 102081102 | CAP, 1 NF, 63V | 09023 | MMP SERIES |
| C302 | 102081102 | CAP, 1 NF, 63V | 09023 | MMP SERIES |
| C303 | 102081104 | CAP, 47 NF, 63V | 09023 | MMP SERIES |
| C304 | 102081101 | CAP, 10 NF, 63V | 09023 | MMP SERIES |
| C305 | 102081101 | CAP, 10 NF, 63V | 09023 | MMP SERIES |
| D1 | 103052217 | LED, RED, HIGH EFFICIENCY | 21793 | 103052217 |
| D2 | 103052217 | LED, RED, HIGH EFFICIENCY | 21793 | 103052217 |
| D3 | 103052217 | LED, RED, HIGH EFFICIENCY | 21793 | 103052217 |
| IC300 | 103011109 | IC | 02735 | CD4012BE |
| IC301 | 103011110 | IC, LCD CONTROLLER | 61892 | UD7225G |
| LCD300 | 103051100 | DISPLAY, LCD, WITH CONNECTOR | 21793 | 103051100 |
| P300 | 101031100 | POT, 10K, LINEAR | 32997 | SERIES 91 |
| P301 | 101031100 | POT, 10K, LINEAR | 32997 | SERIES 91 |
| R300 | 000103 | RES, CARBON, 10K, 1/4W, 5% | 81349 | RC07GF103J |
| R301 | 000103 | RES, CARBON, 10K, 1/4W, 5% | 81349 | RC07GF103J |
| R302 | 000103 | RES, CARBON, 10K, 1/4W, 5% | 81349 | RC07GF103J |
| R303 | 000103 | RES, CARBON, 10K, 1/4W, 5% | 81349 | RC07GF103J |
| R304 | 000223 | RES, CARBON, 22K, 1/4W, 5% | 81349 | RC07GF223J |
| R305 | 000223 | RES, CARBON, 22K, 1/4W, 5% | 81349 | RC07GF223J |
| R306 | 000223 | RES, CARBON, 22K, 1/4W, 5% | 81349 | RC07GF223J |
| R307 | 000223 | RES, CARBON, 22K, 1/4W, 5% | 81349 | RC07GF223J |
| R309 | 000223 | RES, CARBON, 22K, 1/4W, 5% | 81349 | RC07GF223J |

A410-097, DISPLAY PCB (CONT'D)

| REF DESIG. | RACAL-DANA P/N | DESCRIPTION | FSC | MANU P/N |
|---|---|---|---|---|
| R310 | 000223 | RES, CARBON, 22K, 1/4W, 5% | 81349 | RC07GF223J |
| R311 | 000223 | RES, CARBON, 22K, 1/4W, 5% | 81349 | RC07GF223J |
| R312 | 000104 | RES, CARBON, 100K, 1/4W, 5% | 81349 | RC07GF104J |
| R313 | 000104 | RES, CARBON, 100K, 1/4W, 5% | 81349 | RC07GF104J |
| R314 | 000104 | RES, CARBON, 100K, 1/4W, 5% | 81349 | RC07GF104J |
| R315 | 000104 | RES, CARBON, 100K, 1/4W, 5% | 81349 | RC07GF104J |
| R316 | 000184 | RES, CARBON, 180K, 1/4W, 5% | 81349 | RC07GF180J |
| R317 | 000473 | RES, CARBON, 47K, 1/4W, 5% | 81349 | RC07GF473J |
| R318 | 000473 | RES, CARBON, 47K, 1/4W, 5% | 81349 | RC07GF473J |
| R319 | 000221 | RES, CARBON, 220 OHM, 1/4W, 5% | 81349 | RC07GF221J |
| R320 | 000221 | RES, CARBON, 220 OHM, 1/4W, 5% | 81349 | RC07GF221J |
| R321 | 000221 | RES, CARBON, 220 OHM, 1/4W, 5% | 81349 | RC07GF221J |
| S300 | 104091100 | SWITCH | 21793 | 104091100 |
| S310 | 104091100 | SWITCH | 21793 | 104091100 |
| S302 | 104091100 | SWITCH | 21793 | 104091100 |
| S303 | 104091100 | SWITCH | 21793 | 104091100 |
| S304 | 104091100 | SWITCH | 21793 | 104091100 |
| S305 | 104091100 | SWITCH | 21793 | 104091100 |
| S306 | 104091100 | SWITCH | 21793 | 104091100 |
| S307 | 104091100 | SWITCH | 21793 | 104091100 |
| S308 | 104091100 | SWITCH | 21793 | 104091100 |
| S309 | 104091100 | SWITCH | 21793 | 104091100 |
| S310 | 104091100 | SWITCH | 21793 | 104091100 |
| S311 | 104091100 | SWITCH | 21793 | 104091100 |

A410-097, DISPLAY PCB (CONT'D)

| REF DESIG. | RACAL-DANA P/N | DESCRIPTION | FSC | MANU P/N |
|---|---|---|---|---|
| S312 | 104091100 | SWITCH | 21793 | 104091100 |
| S313 | 104091100 | SWITCH | 21793 | 104091100 |
| S314 | 104091100 | SWITCH | 21793 | 104091100 |
| S315 | 104091100 | SWITCH | 21793 | 104091100 |
| S316 | 104091100 | SWITCH | 21793 | 104091100 |
| S317 | 104091100 | SWITCH | 21793 | 104091100 |
| S318 | 104091100 | SWITCH | 21793 | 104091100 |
| S319 | 104091100 | SWITCH | 21793 | 104091100 |

A410-100, ANALOG PCB

| REF DESIG. | RACAL-DANA P/N | DESCRIPTION | FSC | MANU P/N |
|---|---|---|---|---|
| C400 | 102081100 | CAP, 100 NF | 09023 | K63 MMP SERIES |
| C401 | 102041105 | CAP, CERAM, 5.6 PF | 18324 | 683 SERIES |
| C402 | 102081107 | CAP, POLYEST, 1 NF | 21793 | 102081107 |
| C403 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |
| C404 | 102041104 | CAP, CERAM, 47 PF | 18324 | 683 SERIES |
| C405 | 102041104 | CAP, CERAM, 47 PF | 18324 | 683 SERIES |
| C407 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |
| C408 | 102021103 | CAP, RADIAL, 10 MF, 35V | 09023 | CEB SERIES |
| C409 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |
| C410 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |
| C411 | 102081107 | CAP, POLYEST, 1 NF | 21793 | 102081107 |
| C412 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |
| C413 | 102041105 | CAP, CERAM, 5.6 PF | 18324 | 683 SERIES |
| C415 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |
| C416 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |
| C417 | 102131100 | CAP, POLYPROP, 470 PF, 63V | 21793 | 102131100 |
| C418 | 102081100 | CAP, 100 NF | 09023 | K63 MMP SERIES |
| C419 | 102041103 | CAP, CERAM, 220 PF | 18324 | 683 SERIES |
| C420 | 102041103 | CAP, CERAM, 220 PF | 18324 | 683 SERIES |
| C422 | 102041103 | CAP, CERAM, 220 PF | 18324 | 683 SERIES |
| C424 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |
| C426 | 102061102 | CAP, POLYSTY, 33 NF, 63V, 1% | 18324 | 424 SERIES |
| C427 | 102061104 | CAP, POLYSTY, 3.3 NF, 160V, 1% | 18324 | 425 SERIES |
| C428 | 102061105 | CAP, POLYSTY, 1 NF, 160V, 1% | 18324 | 425 SERIES |

A410-100, ANALOG PCB (CONT'D)

| REF DESIG. | RACAL-DANA P/N | DESCRIPTION | FSC | MANU P/N |
|---|---|---|---|---|
| C429 | 102041103 | CAP, CERAM, 220 PF | 18324 | 683 SERIES |
| C430 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |
| C431 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |
| C432 | 102021317 | CAP, RADIAL, 100 MF, 10V | 09023 | CEB SERIES |
| C433 | 102021317 | CAP, RADIAL, 100 MF, 10V | 09023 | CEB SERIES |
| C434 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |
| C435 | 102061100 | CAP, POLYSTY, 68 PF, 160V, 2.5% | 71468 | HS SERIES-AXIAL |
| C436 | 102061011 | CAP, POLYSTY, 10 PF, 160V | 71468 | HS SERIES-AXIAL |
| C437 | 102121274 | CAP, POLYCARB, 100 NF, 100V | 18324 | 344-21104 SERIES |
| C438 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |
| C450 | 102061100 | CAP, POLYSTY, 68 PF, 160V, 2.5% | 71468 | HS SERIES-AXIAL |
| C451 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |
| C453 | 102081101 | CAP 10 NF | 09023 | K63 MMP SERIES |
| C454 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |
| C456 | 102061107 | CAP, POLYSTY, 100 PF, 630V, 1% | 18324 | 427 SERIES |
| C457 | 102061106 | CAP, POLYSTY, 330 PF, 630V, 1% | 18327 | 427 SERIES |
| C458 | 102061103 | CAP, POLYSTY, 10 NF, 63V, 1% | 08324 | 424 SERIES |
| C459 | 102121100 | CAP, POLYCARB, 330 NF, 100V | 08327 | 344-21334 SERIES |
| C460 | 102061102 | CAP, POLYSTY, 33 NF, 63V, 1% | 18324 | 424 SERIES |
| C461 | 102061104 | CAP, POLYSTY, 3.3 NF, 160V, 1% | 18324 | 425 SERIES |
| C462 | 102061105 | CAP, POLYSTY, 1 NF, 160V, 1% | 18324 | 425 SERIES |
| C463 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |
| C464 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |
| C466 | 102061011 | CAP, POLYSTY, 10 PF, 160V, 1% | 71468 | HS SERIES-AXIAL |

A410-100, ANALOG PCB (CONT'D)

| REF DESIG. | RACAL-DANA P/N | DESCRIPTION | FSC | MANU P/N |
|---|---|---|---|---|
| C467 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |
| C468 | 102021215 | CAP, RADIAL, 10 MF, 16V | 09023 | CEB SERIES |
| C469 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |
| C470 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |
| C471 | 102121274 | CAP, POLYCARB, 100 NF, 100V | 18324 | 344-21104 SERIES |
| C472 | 102121100 | CAP, POLYCARB, 330 NF, 100V | 18324 | 344-21334 SERIES |
| C473 | 102061103 | CAP, POLYSTY, 10 NF, 63V, 1% | 18324 | 424 SERIES |
| C474 | 102061106 | CAP, POLYSTY, 330 PF, 630V, 1% | 18324 | 427 SERIES |
| C475 | 102061107 | CAP, POLYSTY, 100 PF, 630V, 1% | 18324 | 427 SERIES |
| C478 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |
| C479 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |
| C480 | 102021215 | CAP, RADIAL, 10 MF, 16V | 09023 | CEB SERIES |
| C481 | 102081100 | CAP, 100 NF | 09023 | K63 MMP SERIES |
| C482 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |
| C483 | 102021215 | CAP, RADIAL, 10 NF, 16V | 09023 | CEB SERIES |
| C484 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |
| C485 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |
| C486 | 102021104 | CAP, RADIAL, 10 MF, 50V | 18324 | K SERIES SUB MIN. |
| C487 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |
| C488 | 102041105 | CAP, CERAM, 5.6 PF | 18324 | 683 SERIES |
| C489 | 102021317 | CAP, RADIAL, 100 MF, 10V | 09023 | CEB SERIES |
| C490 | 102081100 | CAP, 100 NF | 09023 | K63 MMP SERIES |
| C491 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |
| C492 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |

A410-100, ANALOG PCB (CONT'D)

| REF DESIG. | RACAL-DANA P/N | DESCRIPTION | FSC | MANU P/N |
|---|---|---|---|---|
| C493 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |
| C494 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |
| C500 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |
| C501 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |
| C506 | 102041101 | CAP, CERAM, 270 PF | 18324 | 683 SERIES |
| C507 | 102041101 | CAP, CERAM, 270 PF | 18324 | 683 SERIES |
| C513 | 102041101 | CAP, CERAM, 270 PF | 18324 | 683 SERIES |
| C514 | 102041102 | CAP, CERAM 100 PF | 18324 | 683 SERIES |
| C515 | 102041101 | CAP, CERAM, 270 PF | 18324 | 683 SERIES |
| C516 | 102081100 | CAP, 100 NF | 09023 | K63 MMP SERIES |
| C519 | 102041100 | CAP, CERAM, 10 PF | 08324 | 683 SERIES |
| C520 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |
| C521 | 102081100 | CAP, 100 NF | 09023 | K63 MMP SERIES |
| C522 | 102081100 | CAP, 100 NF | 09023 | K63 MMP SERIES |
| C523 | 102021317 | CAP, RADIAL, 100 MF, 10V | 09023 | CEB SERIES |
| C524 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |
| C530 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |
| C531 | 102081105 | CAP, 220 NF, 63V | 09023 | MMP SERIES |
| C532 | 102081105 | CAP, 220 NF, 63V | 09023 | MMP SERIES |
| C533 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |
| C534 | 102041103 | CAP, CERAM, 220 PF | 18324 | 683 SERIES |
| C635 | 102081101 | CAP, 10 NF | 09023 | K63 MMP SERIES |
| C536 | 102041103 | CAP, CERAM, 220 PF | 18324 | 683 SERIES |
| C537 | 102061011 | CAP, POLYSTY, 10 PF | 71468 | HS SERIES-AXIAL |

A410-100, ANALOG PCB (CONT'D)

| REF DESIG. | RACAL-DANA P/N | DESCRIPTION | FSC | MANU P/N |
|---|---|---|---|---|
| C538 | 102061011 | CAP, POLYSTY, 10 PF | 71468 | HS SERIES-AXIAL |
| CON400 | 105041105 | SOCKET, 8-WAY | 27264 | 22-27-2081 SER. KK |
| CON401 | 105041106 | SOCKET, 15-WAY | 27264 | 22-27-2151 SER. KK |
| CON402 | 105041107 | SOCKET, 4-WAY | 27264 | 22-27-2041 SER. KK |
| CON403 | 105041107 | SOCKET, 4-WAY | 27264 | 22-27-2041 SER. KK |
| CON404 | 105041107 | SOCKET, 4-WAY | 27264 | 22-27-2041 SER. KK |
| CON405 | 105041107 | SOCKET, 4-WAY | 27264 | 22-27-2041 SER. KK |
| CON406 | 105041105 | SOCKET, 8-WAY | 27264 | 22-27-2081 SER. KK |
| CON407 | 105041107 | SOCKET, 4-WAY | 27264 | 22-27-2041 SER. KK |
| CON408 | 105041108 | SOCKET, 2-WAY | 27264 | 22-27-2021 SER. KK |
| CON409 | 105041107 | SOCKET, 4-WAY | 27264 | 22-27-2041 SER. KK |
| CON410 | 105041108 | SOCKET, 2-WAY | 27264 | 22-27-2021 SER. KK |
| CON411 | 105041108 | SOCKET, 2-WAY | 27264 | 22-27-2021 SER. KK |
| CON412 | 105041107 | SOCKET, 4-WAY | 27264 | 22-27-2041 SER. KK |
| D400 | 103022043 | DIODE (1N4148) | 21793 | 103022043 |
| D401 | 103021102 | DIODE, HIGH SPEED | 18324 | BAX13 |
| D402 | 103021102 | DIODE, HIGH SPEED | 18324 | BAX13 |
| D403 | 103021102 | DIODE, HIGH SPEED | 18324 | BAX13 |
| D404 | 103022043 | DIODE (1N4148) | 21793 | 103022043 |
| D405 | 103022043 | DIODE (1N4148) | 21793 | 103022043 |
| D406 | 103022043 | DIODE (1N4148) | 21793 | 103022043 |
| D407 | 103022043 | DIODE (1N4148) | 21793 | 103022043 |
| D408 | 103022043 | DIODE (1N4148) | 21793 | 103022043 |

A410-100, ANALOG PCB (CONT'D)

| REF DESIG. | RACAL-DANA P/N | DESCRIPTION | FSC | MANU P/N |
|---|---|---|---|---|
| D409 | 103022043 | DIODE (1N4148) | 21793 | 103022043 |
| D410 | 103022043 | DIODE (1N4148) | 21793 | 103022043 |
| D411 | 103021102 | DIODE, HIGH SPEED | 18324 | BAX13 |
| D412 | 103021101 | DIODE | | 22119ZN404 |
| FB400 | 104021100 | FERRITE BEAD | 21793 | 104021100 |
| FB401 | 104021100 | FERRITE BEAD | 21793 | 104021100 |
| FB402 | 104021100 | FERRITE BEAD | 21793 | 104021100 |
| IC400 | 103011130 | IC | 02735 | CA3096E |
| IC401 | 103011131 | IC | 01295 | TL082CD |
| IC402 | 103012304 | IC | 27014 | LM318N |
| IC403 | 103011121 | IC, OP AMP, 8-PIN DIL | 34371 | HAS2515 |
| IC404 | 103011121 | IC, OP AMP, 8-PIN DIL | 34371 | HAS2515 |
| IC405 | 103011122 | IC, 8-PIN DIL | 02735 | CA3240E |
| IC406 | 103011114 | IC | 18324 | HEF4051BP |
| IC407 | 103011120 | IC | 02735 | CA3280AG |
| IC408 | 103015118 | IC (CD4016CN) | 21793 | 103015118 |
| IC409 | 103011123 | IC | 27014 | DM7407 |
| IC410 | 103012304 | IC | 27014 | LM318N |
| IC411 | 103012304 | IC | 27014 | LM318N |
| IC412 | 103011124 | IC | 24355 | AD7545LN |
| IC413 | 103011114 | IC | 18324 | HEF4051BP |
| IC414 | 103012304 | IC | 27014 | LM318N |
| IC415 | 103011115 | IC | 18324 | HEF4066P |

A410-100, ANALOG PCB (CONT'D)

| REF DESIG. | RACAL-DANA P/N | DESCRIPTION | FSC | MANU P/N |
|---|---|---|---|---|
| IC416 | 103011115 | IC | 18324 | HEF4066P |
| IC417 | 103011125 | IC | 27014 | 74LS123N |
| IC418 | 103012304 | IC | 27014 | LM318N |
| IC419 | 103011124 | IC | 24355 | AD7545LN |
| IC420 | 103011126 | IC | 27014 | LM361N |
| IC421 | 103011115 | IC | 18324 | HEF4066P |
| IC422 | 103011114 | IC | 18324 | HEF4051BP |
| IC423 | 103012304 | IC | 27014 | LM318N |
| IC424 | 103012199 | IC (CD4011BE) | 21793 | 103012199 |
| IC425 | 103015179 | IC (CD4001BE) | 21793 | 103015179 |
| IC426 | 103011127 | IC | 27014 | DM74LS74AN |
| IC427 | 103011126 | IC | 27014 | LM361N |
| IC428 | 103011123 | IC | 27014 | DM7407 |
| IC429 | 103011115 | IC | 18324 | HEF4066P |
| IC430 | 103011128 | IC | 18324 | HEF4052BP |
| IC431 | 103012304 | IC | 27014 | LM318N |
| IC432 | 103012304 | IC | 27014 | LM318N |
| IC433 | 103071100 | IC | 22119 | ZN429E-8 |
| IC434 | 103011115 | IC | 18324 | HEF4066P |
| IC435 | 103012304 | IC | 27014 | LM318N |
| IC436 | 103011115 | IC | 18324 | HEF4066P |
| IC437 | 103012244 | IC (LM324N) | 21793 | 103012244 |
| IC438 | 103012244 | IC (LM324N) | 21793 | 103012244 |
| IC439 | 103011115 | IC | 18324 | HEF4066P |

A410-100, ANALOG PCB (CONT'D)

| REF DESIG. | RACAL-DANA P/N | DESCRIPTION | FSC | MANU P/N |
|---|---|---|---|---|
| L400 | 109011100 | INDUCTOR, 10 UH, (LAL04 KB) | 21793 | 109011100 |
| L401 | 109011100 | INDUCTOR, 10 UH, (LAL04 KB) | 21793 | 109011100 |
| R400 | 000222 | RES, CARBON, 2.2K, 1/4W, 5% | 81349 | RC07GF222J |
| R401 | 000104 | RES, CARBON, 100K, 1/4W, 5% | 81349 | RC07GF104J |
| R402 | 000222 | RES, CARBON, 2.2K, 1/4W, 5% | 81349 | RC07GF222J |
| R403 | 010060 | RES, METAL, 10K, 1/4W, 1% | 81349 | RN60D1002F |
| R404 | 010060 | RES, METAL, 10K, 1/4W, 1% | 81349 | RN60D1002F |
| R405 | 101021219 | RES, METAL, 3.3M, 1/4W, 1% | 21793 | 101021219 |
| R406 | 000105 | RES, CARBON, 1M, 1/4W, 5% | 81349 | RC07GF105J |
| R407 | 000104 | RES, CARBON, 100K, 1/4W, 5% | 81349 | RC07GF104J |
| R408 | 000334 | RES, CARBON, 330K, 1/4W, 5% | 81349 | RC07GF334J |
| R409 | 101021218 | RES, METAL, 33K, 1/4W, 1% | 21793 | 101021218 |
| R410 | 000103 | RES, CARBON, 10K, 1/4W, 5% | 81349 | RC07GF103J |
| R411 | 000102 | RES, CARBON, 1K, 1/4W, 5% | 81349 | RC07GF102J |
| R412 | 000332 | RES, CARBON, 3.3K, 1/4W, 5% | 81349 | RC07GF332J |
| R413 | 101021202 | RES, METAL, 2.2K, 1/4W, 1% | 21793 | 101021202 |
| R414 | 000103 | RES, CARBON, 10K, 1/4W, 5% | 81349 | RC07GF103J |
| R415 | 010060 | RES, METAL, 10K, 1/4W, 1% | 81349 | RN60D1002F |
| R416 | 010060 | RES, METAL, 10K, 1/4W, 1% | 81349 | RN60D1002F |
| R417 | 101021309 | RES, 4.7K, 63 MW, 0.1%, 50 PPM | 21793 | 101021309 |
| R418 | 101021309 | RES, 4.7K, 63 MW, 0.1%, 50 PPM | 21793 | 101021309 |
| R420 | 101020227 | RES, METAL, 10K, 1/4W, 1% | 21793 | 101020227 |
| R421 | 000103 | RES, CARBON, 10K, 1/4W, 5% | 81349 | RC07GF103J |
| R422 | 000103 | RES, CARBON, 10K, 1/4W, 5% | 81349 | RC07GF103J |

A410-100, ANALOG PCB (CONT'D)

| REF DESIG. | RACAL-DANA P/N | DESCRIPTION | FSC | MANU P/N |
|---|---|---|---|---|
| R423 | 000223 | RES, CARBON, 22K, 1/4W, 5% | 81349 | RC07GF223J |
| R424 | 000683 | RES, CARBON, 68K, 1/4W, 5% | 81349 | RC07GF683J |
| R425 | 010137 | RES, METAL, 100 OHM, 1/4W, 1% | 81349 | RN60D1000F |
| R426 | 000222 | RES, CARBON, 2.2K, 1/4W, 5% | 81349 | RC07GF222J |
| R427 | 000222 | RES, CARBON, 2.2K, 1/4W, 5% | 81349 | RC07GF222J |
| R428 | 000103 | RES, CARBON, 10K, 1/4W, 5% | 81349 | RC07GF103J |
| R429 | 000103 | RES, CARBON, 10K, 1/4W, 5% | 81349 | RC07GF103J |
| R430 | 010137 | RES, METAL, 100 OHM, 1/4W, 1% | 81349 | RN60D1000F |
| R431 | 101021212 | RES, METAL, 330 OHM, 1/4W, 1% | 21793 | 101021212 |
| R432 | 010137 | RES, METAL, 100 OHM, 1/4W, 1% | 81349 | RN60D1000F |
| R434 | 101021202 | RES, METAL, 2.2K, 1/4W, 1% | 21793 | 101021202 |
| R435 | 010091 | RES, METAL, 11K, 1/4W, 1% | 81349 | RN60D1102F |
| R436 | 101021221 | RES, METAL FILM, 4.7K, 1/2W, 1% | 21793 | 101021221 |
| R437 | 101021204 | RES, METAL, 110K, 1/4W, 1% | 21793 | 101021204 |
| R439 | 101021212 | RES, METAL, 330 OHM, 1/4W, 1% | 21793 | 101021212 |
| R440 | 000102 | RES, CARBON, 1K, 1/4W, 5% | 81349 | RC07GF102J |
| R442 | 101021221 | RES, METAL FILM, 4.7K, 1/2W, 1% | 21793 | 101021221 |
| R443 | 000102 | RES, CARBON, 1K, 1/4W, 5% | 81349 | RC07GF102J |
| R444 | 010059 | RES, METAL, 20K, 1/4W, 1% | 81349 | RN60D2002F |
| R445 | 101021215 | RES, METAL, 5.1K, 1/4W, 1% | 21793 | 101021215 |
| R446 | 000103 | RES, CARBON, 10K, 1/4W, 5% | 81349 | RC07GF103J |
| R447 | 101021220 | RES, METAL FILM, 3.9K, 1/2W, 1% | 21793 | 101021220 |
| R450 | 010060 | RES, METAL, 10K, 1/4W, 1% | 81349 | RN60D1002F |
| R451 | 101021107 | RES, METAL, 620 OHM, 1/4W, 1% | 21793 | 101021107 |

A410-100, ANALOG PCB (CONT'D)

| REF DESIG. | RACAL-DANA P/N | DESCRIPTION | FSC | MANU P/N |
|---|---|---|---|---|
| R452 | 010060 | RES, METAL, 10K, 1/4W, 1% | 81349 | RN60D1002F |
| R453 | 101021107 | RES, METAL, 620 OHM, 1/4W, 1% | 21793 | 101021107 |
| R454 | 000103 | RES, CARBON, 10K, 1/4W, 5% | 81349 | RC07GF103J |
| R456 | 000104 | RES, CARBON, 100K, 1/4W, 5% | 81349 | RC07GF104J |
| R457 | 000223 | RES, CARBON, 22K, 1/4W, 5% | 81349 | RC07GF223J |
| R458 | 000223 | RES, CARBON, 22K, 1/4W, 5% | 81349 | RC07GF223J |
| R459 | 000104 | RES, CARBON, 100K, 1/4W, 5% | 81349 | RC07GF104J |
| R460 | 010059 | RES, METAL, 20K, 1/4W, 1% | 81349 | RN60D2002F |
| R461 | 000223 | RES, CARBON, 22K, 1/4W, 5% | 81349 | RC07GF223J |
| R462 | 000512 | RES, CARBON, 5.1K, 1/4W, 5% | 81349 | RC07GF512J |
| R463 | 101021220 | RES, METAL FILM, 3.9K, 1/2W, 1% | 21793 | 101021220 |
| R465 | 000102 | RES, CARBON, 1K, 1/4W, 5% | 81349 | RC07GF102J |
| R466 | 000222 | RES, CARBON, 2.2K, 1/4W, 5% | 81349 | RC07GF222J |
| R468 | 101021312 | RES, 12K, 63 MW, 0.1% | 21793 | 101021312 |
| R469 | 101021301 | RES, 8.2K, 63 MW, 0.1% | 21793 | 101021301 |
| R470 | 000470 | RES, CARBON, 47 OHM ,1/4W, 5% | 81349 | RC07GF470J |
| R471 | 000470 | RES, CARBON, 47 OHM ,1/4W, 5% | 81349 | RC07GF470J |
| R472 | 101021303 | RES, 5.6K, 63 MW, 0.1% | 21793 | 101021303 |
| R473 | 101021303 | RES, 5.6K, 63 MW, 0.1% | 21793 | 101021303 |
| R475 | 000223 | RES, CARBON, 22K, 1/4W, 5% | 81349 | RC07GF223J |
| R476 | 000104 | RES, CARBON, 100K, 1/4W, 5% | 81349 | RC07GF104J |
| R478 | 000102 | RES, CARBON, 1K, 1/4W, 5% | 81349 | RC07GF102J |
| R479 | 000103 | RES, CARBON, 10K, 1/4W, 5% | 81349 | RC07GF103J |
| R480 | 001737 | RES, FSV | 21793 | 001737 |

A410-100, ANALOG PCB (CONT'D)

| REF DESIG. | RACAL-DANA P/N | DESCRIPTION | FSC | MANU P/N |
|---|---|---|---|---|
| R481 | 000222 | RES, CARBON, 2.2K, 1/4W, 5% | 81349 | RC07GF222J |
| R482 | 000102 | RES, CARBON, 1K, 1/4W, 5% | 81349 | RC07GF102J |
| R483 | 001737 | RES, FSV | 21793 | 001737 |
| R484 | 101021210 | RES, METAL, 51 OHM, 1/4W, 1% | 21793 | 101021210 |
| R485 | 101021207 | RES, METAL, 2.4K, 1/4W, 1% | 21793 | 101021207 |
| R486 | 101021210 | RES, METAL, 51 OHM, 1/4W, 1% | 21793 | 101021210 |
| R487 | 000102 | RES, CARBON, 1K, 1/4W, 5% | 81349 | RC07GF102J |
| R488 | 101021209 | RES, METAL, 8.2K, 1/4W, 1% | 21793 | 101021209 |
| R489 | 000104 | RES, CARBON, 100K, 1/4W, 5% | 81349 | RC07GF104J |
| R490 | 000472 | RES, CARBON, 4.7K, 1/4W, 5% | 81349 | RC07GF472J |
| R491 | 101021218 | RES, METAL, 33K, 1/4W, 1% | 21793 | 101021218 |
| R492 | 101021209 | RES, METAL, 8.2K, 1/4W, 1% | 21793 | 101021209 |
| R493 | 101021208 | RES, METAL, 22K, 1/4W, 1% | 21793 | 101021208 |
| R494 | 000472 | RES, CARBON, 4.7K, 1/4W, 5% | 81349 | RC07GF472J |
| R495 | 101020807 | RES, 10K, 63 MW, 0.1%, 50 PPM | 21793 | 101020807 |
| R496 | 101021208 | RES, METAL, 22K, 1/4W, 1% | 21793 | 101021208 |
| R497 | 101021108 | RES, METAL, 6.2K, 1/4W, 1% | 21793 | 101021108 |
| R498 | 000105 | RES, CARBON, 1M, 1/4W, 5% | 81349 | RC07GF105J |
| R499 | 101021213 | RES, METAL, 1.8K, 1/4W, 1% | 21793 | 101021213 |
| R500 | 101021310 | RES, 600 OHM, 63 MW, 0.1%, 50 PPM | 21793 | 101021310 |
| R501 | 101021304 | RES, 510 OHM, 63 MW, 0.1%, 50 PPM | 21793 | 101021304 |
| R502 | 010523 | RES, METAL, 13K, 1/4W, 1% | 81349 | RN60D1302F |
| R503 | 010523 | RES, METAL, 13K, 1/4W, 1% | 81349 | RN60D1302F |
| R504 | 101021304 | RES, 510 OHM, 63 MW, 0.1%, 50 PPM | 21793 | 101021304 |
| R505 | 101020833 | RES, 130 OHM, 63 MW, 0.1%, 50 PPM | 21793 | 101020833 |

A410-100, ANALOG PCB (CONT'D)

| REF DESIG. | RACAL-DANA P/N | DESCRIPTION | FSC | MANU P/N |
|---|---|---|---|---|
| R506 | 101021305 | RES, 620 OHM, 63 MW, 0.1%, 50 PPM | 21793 | 101021305 |
| R507 | 010091 | RES, METAL, 11K, 1/4W, 1% | 81349 | RN60D1102F |
| R508 | 000103 | RES, CARBON, 10K, 1/4W, 5% | 81349 | RC07GF103J |
| R509 | 000103 | RES, CARBON, 10K, 1/4W, 5% | 81349 | RC07GF103J |
| R510 | 000223 | RES, CARBON, 22K, 1/4W, 5% | 81349 | RC07GF223J |
| R511 | 001737 | RES, FSV | 21793 | 001737 |
| R512 | 001737 | RES, FSV | 21793 | 001737 |
| R513 | 001737 | RES, FSV | 21793 | 001737 |
| R514 | 101021216 | RES, METAL, 9.1K, 1/4W, 1% | 81349 | RN60D9101F |
| R515 | 010059 | RES, METAL, 20K, 1/4W, 1% | 81349 | RN60D2002F |
| R519 | 101021311 | RES, 12 OHM, 63 MW, 0.1%, 50 PPM | 21793 | 101021311 |
| R520 | 000103 | RES, CARBON, 10K, 1/4W, 5% | 81349 | RC07GF103J |
| R521 | 000103 | RES, CARBON, 10K, 1/4W, 5% | 81349 | RC07GF103J |
| R522 | 000334 | RES, CARBON, 330K, 1/4W, 5% | 81349 | RC07GF334J |
| R523 | 000334 | RES, CARBON, 330K, 1/4W, 5% | 81349 | RC07GF334J |
| R524 | 000223 | RES, CARBON, 22K, 1/4W, 5% | 81349 | RC07GF223J |
| R525 | 000223 | RES, CARBON, 22K, 1/4W, 5% | 81349 | RC07GF223J |
| R526 | 000223 | RES, CARBON, 22K, 1/4W, 5% | 81349 | RC07GF223J |
| R527 | 000102 | RES, CARBON, 1K, 1/4W, 5% | 81349 | RC07GF102J |
| R528 | 000102 | RES, CARBON, 1K, 1/4W, 5% | 81349 | RC07GF102J |
| R529 | 010091 | RES, METAL, 11K, 1/4W, 1% | 81349 | RN60D1102F |
| R530 | 101021208 | RES, METAL, 22K, 1/4W, 1% | 81349 | RN60D2202F |
| R531 | 000104 | RES, CARBON, 100K, 1/4W, 5% | 81349 | RC07GF104J |
| R532 | 101021305 | RES, 620 OHM, 63 MV, 1.0%, 50 PPM | 21793 | 101021305 |

A410-100, ANALOG PCB (CONT'D)

| REF DESIG. | RACAL-DANA P/N | DESCRIPTION | FSC | MANU P/N |
|---|---|---|---|---|
| R533 | 010091 | RES, METAL, 11K, 1/4W, 1% | 81349 | RN60D1102F |
| R538 | 000104 | RES, CARBON, 100K, 1/4W, 5% | 81349 | RC07GF104J |
| R539 | 000104 | RES, CARBON, 100K, 1/4W, 5% | 81349 | RC07GF104J |
| R541 | 101021208 | RES, METAL, 22K, 1/4W, 1% | 81349 | RN60D2202F |
| R542 | 000101 | RES, CARBON, 100 OHM, 1/4W, 5% | 81349 | RC07GF101J |
| R543 | 000101 | RES, CARBON, 100 OHM, 1/4W, 5% | 81349 | RC07GF101J |
| R544 | 001737 | RES, FSV | 21793 | 001737 |
| R545 | 000331 | RES, CARBON, 330 OHM, 1/4W, 5% | 81349 | RC07GF331J |
| R546 | 000562 | RES, CARBON, 5.6K, 1/4W, 5% | 81349 | RC07GF562J |
| R547 | 000562 | RES, CARBON, 5.6K, 1/4W, 5% | 81349 | RC07GF562J |
| RP400 | 101041101 | RES NETWORK, 4.7K, 8-PIN SIL | 21793 | 101041101 |
| RP401 | 101041101 | RES NETWORK, 4.7K, 8-PIN SIL | 21793 | 101041101 |
| RP402 | 101041102 | RES, NETWORK, 100K, 6-PIN SIL | 21793 | 101041102 |
| RP403 | 101041102 | RES, NETWORK, 100K, 6-PIN SIL | 21793 | 101041102 |
| RP404 | 101041102 | RES, NETWORK, 100K, 6-PIN SIL | 21793 | 101041102 |
| RLY400 | 105081100 | RELAY (SDS: DS2E-MIL2-DC5V) | 21793 | 105081100 |
| RLY401 | 105081100 | RELAY (SDS: DS2E-MIL2-DC5V) | 21793 | 105081100 |
| TR400 | 103032150 | TRANSISTOR | 27014 | BC214 |
| TR401 | 103032149 | TRANSISTOR | 27014 | BC184 |
| TR402 | 103031102 | TRANSISTOR | 27014 | 2N2369 |
| TR405 | 103031100 | TRANSISTOR | 22119 | ZTX450 |
| TR406 | 103032149 | TRANSISTOR | 27014 | BC184 |
| TR407 | 103032150 | TRANSISTOR | 27014 | BC214 |

A410-100, ANALOG PCB (CONT'D)

| REF DESIG. | RACAL-DANA P/N | DESCRIPTION | FSC | MANU P/N |
|---|---|---|---|---|
| TR408 | 103032150 | TRANSISTOR | 27014 | BC214 |
| TR409 | 103032150 | TRANSISTOR | 27014 | BC214 |
| TR410 | 103032150 | TRANSISTOR | 27014 | BC214 |
| TR411 | 103032149 | TRANSISTOR | 27014 | BC184 |
| Z400 | 103021100 | DIODE, ZENER (BZX79C7V5) | 21793 | 103021100 |
| Z401 | 103021100 | DIODE, ZENER (BZX79C7V5) | 21793 | 103021100 |

A410-098, DIGITAL PCB

| REF DESIG. | RACAL-DANA P/N | DESCRIPTION | FSC | MANU P/N |
|---|---|---|---|---|
| BR101 | 103061101 | RECTIFIER, BRIDGE | 21793 | 103061101 |
| BR102 | 103061100 | RECTIFIER, BRIDGE | 21793 | 103061100 |
| C101 | 102031033 | CAP, 2200 MF, 40V | 18324 | 033 SERIES-17222 |
| C102 | 102031196 | CAP, 4700 MF, 16V | 18324 | 033 SERIES-15472 |
| C103 | 102031033 | CAP, 2200 MF, 40V | 18324 | 033 SERIES-17222 |
| C104 | 102121275 | CAP, 10 NF, 400V | 18324 | 344-511 03 SERIES |
| C105 | 102121275 | CAP, 10 NF, 400V | 18324 | 344-511 03 SERIES |
| C106 | 102121275 | CAP, 10 NF, 400V | 18324 | 344-511 03 SERIES |
| C107 | 102121275 | CAP, 10 NF, 400V | 18324 | 344-511 03 SERIES |
| C108 | 102121275 | CAP, 10 NF, 400V | 18324 | 344-511 03 SERIES |
| C109 | 102121275 | CAP, 10 NF, 400V | 18324 | 344-511 03 SERIES |
| C110 | 102021100 | CAP, 100 MF, 25V, RADIAL | 09023 | CEB SERIES |
| C111 | 102021100 | CAP, 100 MF, 25V, RADIAL | 09023 | CEB SERIES |
| C112 | 102081101 | CAP, 10 NF, 63V | 09023 | MMP SERIES |
| C113 | 102081101 | CAP, 10 NF, 63V | 09023 | MMP SERIES |
| C114 | 102081101 | CAP, 10 NF, 63V | 09023 | MMP SERIES |
| C115 | 102081101 | CAP, 10 NF, 63V | 09023 | MMP SERIES |
| C126 | 102081100 | CAP, 100 NF, 63V | 09023 | MMP SERIES |
| C127 | 102081106 | CAP, 6.8 NF, 100V | 21793 | 102081106 |
| C128 | 102081106 | CAP, 6.8 NF, 100V | 21793 | 102081106 |
| C129 | 102081101 | CAP, 10 NF, 63V | 09023 | MMP SERIES |
| C130 | 102081101 | CAP, 10 NF, 63V | 09023 | MMP SERIES |
| C131 | 102081102 | CAP, POLYEST, 1 NF, 63V | 09023 | MMP SERIES |
| C132 | 102081100 | CAP, 100 NF, 63V | 09023 | MMP SERIES |

A410-098, DIGITAL PCB (CONT'D)

| REF DESIG. | RACAL-DANA P/N | DESCRIPTION | FSC | MANU P/N |
|---|---|---|---|---|
| C133 | 102081100 | CAP, 100 NF, 63V | 09023 | MMP SERIES |
| C134 | 102081100 | CAP, 100 NF, 63V | 09023 | MMP SERIES |
| C135 | 102081100 | CAP, 100 NF, 63V | 09023 | MMP SERIES |
| C136 | 102021101 | CAP, 100 MF, 10V, RADIAL | 09023 | CEB SERIES |
| C137 | 102081100 | CAP, 100 NF, 63V | 09023 | MMP SERIES |
| C138 | 102081100 | CAP, 100 NF, 63V | 09023 | MMP SERIES |
| C139 | 102081100 | CAP, 100 NF, 63V | 09023 | MMP SERIES |
| C140 | 102081100 | CAP, 100 NF, 63V | 09023 | MMP SERIES |
| C141 | 102081100 | CAP, 100 NF, 63V | 09023 | MMP SERIES |
| C142 | 102081100 | CAP, 100 NF, 63V | 09023 | MMP SERIES |
| C143 | 102081100 | CAP, 100 NF, 63V | 09023 | MMP SERIES |
| C144 | 102081102 | CAP, POLYEST, 1 NF, 63V | 09023 | MMP SERIES |
| C145 | 102081100 | CAP, 100 NF, 63V | 09023 | MMP SERIES |
| C146 | 102081100 | CAP, 100 NF, 63V | 09023 | MMP SERIES |
| CON101 | 105041105 | CONNECTOR, 8-WAY | 27264 | SERIES KK/22-27-2081 |
| CON102 | 105041107 | CONNECTOR, 4-WAY | 27264 | SERIES KK/22-27-2041 |
| CON103 | 105041107 | CONNECTOR, 4-WAY | 27264 | SERIES KK/22-27-2041 |
| CON104A | 105041117 | CONNECTOR, 5-WAY, .1" WAFER | 27264 | 641 SERIES |
| CON104B | 105042962 | CONNECTOR, 20-WAY, .1" WAFER | 27264 | 410 SERIES |
| CON105 | 105041105 | CONNECTOR, 8-WAY | 27264 | SERIES KK/22-27-2081 |
| CON106 | 105041107 | CONNECTOR, 4-WAY | 27264 | SERIES KK/22-27-2041 |
| CON107 | 105041105 | CONNECTOR, 15-WAY | 27264 | SERIES KK/22-27-2151 |
| CON108 | 105041107 | CONNECTOR, 4-WAY | 27264 | SERIES KK/22-27-2041 |
| CON109 | 105041107 | CONNECTOR, 4-WAY | 27264 | SERIES KK/22-27-2041 |

A410-098, DIGITAL PCB (CONT'D)

| REF DESIG. | RACAL-DANA P/N | DESCRIPTION | FSC | MANU P/N |
|---|---|---|---|---|
| CON110 | 105041105 | CONNECTOR, 8-WAY | 27264 | SERIES KK/22-27-2081 |
| D100 | 103022011 | DIODE, ZENER, 5.6V | 21793 | 103022011 |
| IC100 | 103011101 | IC, R6502P C.P.U. | 21793 | 103011101 |
| IC101 | 103011106 | IC, R6522P V.I.A. | 21793 | 103011106 |
| IC102 | 103011111 | IC | 04713 | MC6821P |
| IC104 | 103011112 | IC, NON-VOLATIVE RAM CHIP | 21793 | 103011112 |
| IC105 | 103011105 | IC, EPROM | 52531 | HN482764G-4 |
| IC106 | 103011105 | IC, EPROM | 52531 | HN482764G-4 |
| IC107 | 230193 | IC | 27014 | 74LS00N |
| IC108 | 230368 | IC | 27014 | 74LS138N |
| IC109 | 103011113 | IC | 27014 | CD4042BCN |
| IC110 | 103011113 | IC | 27014 | CD4042BCN |
| IC111 | 103011113 | IC | 27014 | CD4042BCN |
| IC112 | 103011113 | IC | 27014 | CD4042BCN |
| IC113 | 103011113 | IC | 27014 | CD4042BCN |
| IC114 | 103011113 | IC | 27014 | CD4042BCN |
| IC115 | 103011113 | IC | 27014 | CD4042BCN |
| IC116 | 103011113 | IC | 27014 | CD4042BCN |
| IC117 | 103011114 | IC | 18324 | HEF4051P |
| IC118 | 103011115 | IC | 18324 | HEF4066P |
| IC119 | 103015116 | IC | 02735 | CD4013B |
| IC120 | 230194 | IC | 27014 | 74LS74N |
| IC121 | 103011116 | IC | 02735 | CD4093B |

A410-098, DIGITAL PCB (CONT'D)

| REF DESIG. | RACAL-DANA P/N | DESCRIPTION | FSC | MANU P/N |
|---|---|---|---|---|
| IC123 | 103011115 | IC | 18324 | HEF4066P |
| IC124 | 103011115 | IC | 18324 | HEF4066P |
| IC125 | 103011100 | IC | 27014 | LM556CN |
| IC126 | 103011118 | IC, REGULATOR | 27014 | LM340T-15 |
| IC127 | 103012308 | IC, REGULATOR | 27014 | LM340T-5 |
| IC128 | 103011119 | IC, REGULATOR | 27014 | LM7915CT-15 |
| IC129 | 103011100 | IC | 27014 | LM556CN |
| R100 | 000472 | RES, CARBON, 4.7K, 1/4W, 5% | 81349 | RC07GF472J |
| R101 | 000472 | RES, CARBON, 4.7K, 1/4W, 5% | 81349 | RC07GF472J |
| R102 | 000472 | RES, CARBON, 4.7K, 1/4W, 5% | 81349 | RC07GF472J |
| R105 | 000472 | RES, CARBON, 4.7K, 1/4W, 5% | 81349 | RC07GF472J |
| R106 | 000472 | RES, CARBON, 4.7K, 1/4W, 5% | 81349 | RC07GF472J |
| R113 | 000104 | RES, CARBON, 100K, 1/4W, 5% | 81349 | RC07GF104J |
| R114 | 000104 | RES, CARBON, 100K, 1/4W, 5% | 81349 | RC07GF104J |
| R115 | 000104 | RES, CARBON, 100K, 1/4W, 5% | 81349 | RC07GF104J |
| R116 | 000104 | RES, CARBON, 100K, 1/4W, 5% | 81349 | RC07GF104J |
| R117 | 000104 | RES, CARBON, 100K, 1/4W, 5% | 81349 | RC07GF104J |
| R118 | 000104 | RES, CARBON, 100K, 1/4W, 5% | 81349 | RC07GF104J |
| R119 | 000104 | RES, CARBON, 100K, 1/4W, 5% | 81349 | RC07GF104J |
| R120 | 000223 | RES, CARBON, 22K, 1/4W, 5% | 81349 | RC07GF223J |
| R122 | 000223 | RES, CARBON, 22K, 1/4W, 5% | 81349 | RC07GF223J |
| R132 | 000104 | RES, CARBON, 100K, 1/4W, 5% | 81349 | RC07GF104J |
| R133 | 000223 | RES, CARBON, 22K, 1/4W, 5% | 81349 | RC07GF223J |
| R134 | 000223 | RES, CARBON, 22K, 1/4W, 5% | 81349 | RC07GF223J |

A410-098, DIGITAL PCB (CONT'D)

| REF DESIG. | RACAL-DANA P/N | DESCRIPTION | FSC | MANU P/N |
|---|---|---|---|---|
| R135 | 101020206 | RES, METAL, 220 OHM, 1/4W, 2% | 21793 | 101020206 |
| R136 | 101021102 | RES, METAL, 470K, 1/4W, 2% | 21793 | 101021102 |
| R137 | 101020212 | RES, METAL, 1K, 1/4W, 2% | 21793 | 101020212 |
| R138 | 000472 | RES, CARBON, 4.7K, 1/4W, 5% | 81349 | RC07GF472J |
| R139 | 000472 | RES, CARBON, 4.7K, 1/4W, 5% | 81349 | RC07GF472J |
| R140 | 000225 | RES, CARBON, 2.2M, 1/4W, 5% | 81349 | RC07GF225J |
| R141 | 000472 | RES, CARBON, 4.7K, 1/4W, 5% | 81349 | RC07GF472J |
| R142 | 000472 | RES, CARBON, 4.7K, 1/4W, 5% | 81349 | RC07GF472J |
| R143 | 000472 | RES, CARBON, 4.7K, 1/4W, 5% | 81349 | RC07GF472J |
| R144 | 000472 | RES, CARBON, 4.7K, 1/4W, 5% | 81349 | RC07GF472J |
| R148 | 000472 | RES, CARBON, 4.7K, 1/4W, 5% | 81349 | RC07GF472J |
| R150 | 101020212 | RES, METAL, 1K, 1/4W, 2% | 21793 | 101020212 |
| R151 | 101021102 | RES, METAL, 470K, 1/4W, 2% | 21793 | 101021102 |
| R152 | 101020206 | RES, METAL, 220 OHM, 1/4W, 2% | 21793 | 101020206 |
| RP100 | 101041100 | RESISTOR PACK, 22K, SIL, 6-PIN | 21793 | 101041100 |
| SW100 | 105121100 | SWITCH | 21793 | 105121100 |
| TR100 | 103032149 | TRANSISTOR, BC184B | 21793 | 103032149 |
| TR101 | 103032149 | TRANSISTOR, BC184B | 21793 | 103032149 |

**A410-007, IEEE-488 PCB**

| REF DESIG. | RACAL-DANA P/N | DESCRIPTION | FSC | MANU P/N |
|---|---|---|---|---|
| BR200 | 103061100 | BRIDGE RECTIFIER (2KBB10R) | 21793 | 103061100 |
| C200 | 102031100 | CAP, 470 MF, 25V | 18324 | CEA SERIES |
| C201 | 102031101 | CAP, 2200 MF, 25V | 18324 | CEA SERIES |
| C202 | 102031100 | CAP, 470 MF, 25V | 18324 | CEA SERIES |
| C203 | 102081103 | CAP, 470 NF, 63V | 09023 | MMP SERIES |
| C204 | 102081101 | CAP, 10 NF, 63V | 09023 | MMP SERIES |
| C205 | 102081103 | CAP, 470 NF, 63V | 09023 | MMP SERIES |
| C206 | 102081101 | CAP, 10 NF, 63V | 09023 | MMP SERIES |
| C207 | 102021102 | CAP, 4.7 MF, 35V | 09023 | CEB SERIES |
| C208 | 102081104 | CAP, 47 NF, 63V | 09023 | MMP SERIES |
| C209 | 102021102 | CAP, 4.7 MF, 35V | 09023 | CEB SERIES |
| C210 | 102081104 | CAP, 47 NF, 63V | 09023 | MMP SERIES |
| C211 | 102081104 | CAP, 47 NF, 63V | 09023 | MMP SERIES |
| C212 | 102081104 | CAP, 47 NF, 63V | 09023 | MMP SERIES |
| C213 | 102081104 | CAP, 47 NF, 63V | 09023 | MMP SERIES |
| C214 | 102081101 | CAP, 10 NF, 63V | 09023 | MMP SERIES |
| C215 | 102081101 | CAP, 10 NF, 63V | 09023 | MMP SERIES |
| C216 | 102081101 | CAP, 10 NF, 63V | 09023 | MMP SERIES |
| C217 | 102081105 | CAP, 220 NF, 63V | 09023 | MMP SERIES |
| C218 | 102021102 | CAP, 4.7 MF, 35V | 09023 | CEB SERIES |
| C219 | 102081104 | CAP, 47 NF, 63V | 09023 | MMP SERIES |
| C220 | 102081104 | CAP, 47 NF, 63V | 09023 | MMP SERIES |
| C221 | 102081104 | CAP, 47 NF, 63V | 09023 | MMP SERIES |
| C222 | 102081104 | CAP, 47 NF, 63V | 09023 | MMP SERIES |

A410-007, IEEE-488 PCB (CONT'D)

| REF DESIG. | RACAL-DANA P/N | DESCRIPTION | FSC | MANU P/N |
|---|---|---|---|---|
| C223 | 102081104 | CAP, 47 NF, 63V | 09023 | MMP SERIES |
| C224 | 102081104 | CAP, 47 NF, 63V | 09023 | MMP SERIES |
| CON200 | 105041103 | CONNECTOR, 24-WAY GPIB KIT | 02660 | 552791-1/552633-4 |
| CON202 | 105041111 | CONNECTOR, 24-WAY RS232-C | 71468 | DBPF25V6 |
| D200 | 103022011 | DIODE, ZENER, BZY88 56V | 21793 | 103022011 |
| D202 | 103021001 | DIODE, 1N4000 | 21793 | 103021001 |
| D203 | 103021001 | DIODE, 1N4000 | 21793 | 103021001 |
| IC200 | 230193 | IC | 27014 | 74LS00N |
| IC201 | 103011100 | IC | 27014 | LM556CN |
| IC202 | 103011101 | IC, R6502P, C.P.U. | 21793 | 103011101 |
| IC203 | 103011102 | IC, GPIB CONTROLLER | 04713 | MC68488P |
| IC204 | 103011103 | IC, GPIB DRIVERS | 04713 | MC3447-P |
| IC205 | 103011103 | IC, GPIB DRIVERS | 04713 | MC3447-P |
| IC206 | 103011104 | IC, RAM | 52531 | HM6116P-4 |
| IC207 | 103011105 | IC, EPROM | 52531 | HN482764G-4 |
| IC208 | 230368 | IC | 27014 | 74LS138N |
| IC209 | 103016025 | IC, ACIA | 04713 | MC6805P |
| IC210 | 103011106 | IC, R6522P V.I.A. | 21793 | 103011106 |
| IC211 | 103011117 | IC, LM7805 CT 5V REGULATOR | 21793 | 103011117 |
| IC212 | 103016030 | IC, LINE RECEIVER | 27014 | MC1489N |
| IC213 | 103016029 | IC, LINE DRIVER | 27014 | MC1488N |
| IC214 | 103011107 | IC, OPTO ISOLATORS, 6-PIN DIL | 01295 | TIL117 |
| IC215 | 103011107 | IC, OPTO ISOLATORS, 6-PIN DIL | 01295 | TIL117 |

A410-007, IEEE-488 PCB (CONT'D)

| REF DESIG. | RACAL-DANA P/N | DESCRIPTION | FSC | MANU P/N |
|---|---|---|---|---|
| IC216 | 103011107 | IC, OPTO ISOLATORS, 6-PIN DIL | 01295 | TIL117 |
| IC217 | 103011107 | IC, OPTO ISOLATORS, 6-PIN DIL | 01295 | TIL117 |
| IC218 | 103011107 | IC, OPTO ISOLATORS, 6-PIN DIL | 01295 | TIL117 |
| IC219 | 230234 | IC | 27014 | 74LS04N |
| IC220 | 103011108 | IC | 27014 | DM74LS126N |
| IC221 | 103011108 | IC | 27014 | DM74LS126N |
| R200 | 000472 | RES, CARBON, 4.7K, 1/4W, 5% | 81349 | RC07GF472J |
| R201 | 000511 | RES, CARBON, 510 OHM, 1/4W, 5% | 81349 | RC07GF511J |
| R202 | 000682 | RES, CARBON, 6.8K, 1/4W, 5% | 81349 | RC07GF682J |
| R204 | 000472 | RES, CARBON, 4.7K, 1/4W, 5% | 81349 | RC07GF472J |
| R206 | 000472 | RES, CARBON, 4.7K, 1/4W, 5% | 81349 | RC07GF472J |
| R207 | 000472 | RES, CARBON, 4.7K, 1/4W, 5% | 81349 | RC07GF472J |
| R209 | 000472 | RES, CARBON, 4.7K, 1/4W, 5% | 81349 | RC07GF472J |
| R210 | 000682 | RES, CARBON, 6.8K, 1/4W, 5% | 81349 | RC07GF682J |
| R211 | 000682 | RES, CARBON, 6.8K, 1/4W, 5% | 81349 | RC07GF682J |
| R213 | 101021100 | RES, METAL, 2.2M, 1/4W, 2% | 21793 | 101021100 |
| R214 | 000101 | RES, CARBON, 100 OHM, 1/4W, 5% | 81349 | RC07GF101J |
| R215 | 000511 | RES, CARBON, 510 OHM, 1/4W, 5% | 81349 | RC07GF511J |
| R216 | 000101 | RES, CARBON, 100 OHM, 1/4W, 5% | 81349 | RC07GF101J |
| R217 | 000511 | RES, CARBON, 510 OHM, 1/4W, 5% | 81349 | RC07GF511J |
| R218 | 000101 | RES, CARBON, 100 OHM, 1/4W, 5% | 81349 | RC07GF101J |
| R219 | 000511 | RES, CARBON, 510 OHM, 1/4W, 5% | 81349 | RC07GF511J |
| R220 | 000101 | RES, CARBON, 100 OHM, 1/4W, 5% | 81349 | RC07GF101J |
| R221 | 000511 | RES, CARBON, 510 OHM, 1/4W, 5% | 81349 | RC07GF511J |

A410-007, IEEE-488 PCB (CONT'D)

| REF DESIG. | RACAL-DANA P/N | DESCRIPTION | FSC | MANU P/N |
|---|---|---|---|---|
| R222 | 000101 | RES, CARBON, 100 OHM, 1/4W, 5% | 81349 | RC07GF101J |
| R223 | 000472 | RES, CARBON, 4.7K, 1/4W, 5% | 81349 | RC07GF472J |
| R224 | 000472 | RES, CARBON, 4.7K, 1/4W, 5% | 81349 | RC07GF472J |
| R225 | 000472 | RES, CARBON, 4.7K, 1/4W, 5% | 81349 | RC07GF472J |
| R226 | 000472 | RES, CARBON, 4.7K, 1/4W, 5% | 81349 | RC07GF472J |
| R228 | 000472 | RES, CARBON, 4.7K, 1/4W, 5% | 81349 | RC07GF472J |
| R229 | 000472 | RES, CARBON, 4.7K, 1/4W, 5% | 81349 | RC07GF472J |
| R230 | 000472 | RES, CARBON, 4.7K, 1/4W, 5% | 81349 | RC07GF472J |
| RP200 | 101041101 | RES PKG, 4.7K SIL, 8-PIN | 21793 | 101041101 |
| SW200 | 105121101 | SWITCH, DIL 8-WAY LVR, SPST | 21793 | 105121101 |
| TR200 | 103032149 | TRANSISTOR, NPN, BC337 | 21793 | 103032149 |
| TR201 | 103032149 | TRANSISTOR, NPN, BC337 | 21793 | 103032149 |

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## REPAIR REQUEST FORM

To allow us to better understand your repair requests, we suggest you use the following outline and include a copy with your instrument to be sent to your local Racal-Dana repair facility.

Model Number _____ Options _____ Date _____

Serial Number _____ P. O.# _____

Company Name _____

Address _____

City _____ State _____ Zip Code _____

Contact _____ Phone Number _____

1. Describe, in detail, the problem and symptoms you are having.

_____

_____

2. If you are using your unit on the bus, please list the program strings used and the controller type, if possible.

_____

_____

3. List all input levels, and frequencies this failure occurs.

_____

_____

4. Indicate any repair work previously performed.

_____

_____

5. Please give any additional information you feel would be beneficial in facilitating a faster repair time. (I. E., modifications, etc.)

_____

_____

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